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PROGRESS REPORT NO. 2 - MAY 1983 WATER QUALITY SAMPLING IN MYRA CREEK AT WESTMIN RESOURCES LTD. MINE ON VANCOUVER ISLAND

Regional Program Report 84 - 01

By

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ABSTRACT

The Environmental Protection Service conducted a monitoring program in May 1983 to determine whether continued modifications to the collection and treatment works at Westmin Resources had resulted in improvements in Myra Creek water quality. Conductivity, residues, turbidity, sulphates, pH and total and dissolved metals were recorded. Mean copper, zinc and sulphate loadings were calculated. The Lynx pond discharge and any acid mine drainage that escaped collection and treatment appeared to be primarily responsible for the elevated copper and zinc levels in Myra Creek. The Myra ponds discharge mainly contributed to increased residue, sulphate and hardness concentrations. Metal and sulphate levels in Myra Creek were less in May 1983 than in December 1982.

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1. INTRODUCTION

Westmin Resources Ltd. is presently operating the Lynx and Myra underground copper-lead-zinc mines in Strathcona Provincial Park on Vancouver Island. The mines are located at the south end of Buttle Lake, approximately 93 kilometers by road from Campbell River, B.C. (Figure 1). Both mines have been in operation since the late sixties or early seventies but elevated metal levels in Myra Creek have not been of major environmental concern until very recently.

Since 1966, reports have been published by various government agencies and private consultants regarding the probable and actual effects of the discharge of mine tailings into Buttle Lake. In comparison, little attention has been given to effects of mine site drainage on Myra Creek or other streams in the area. The geology of the area was known to be conducive to acid generation and increased solubilization of metals. Therefore, metal loadings into Buttle Lake via creeks draining the mine site were anticipated. However, metal loading into Buttle Lake from artificial sources (i.e. tailings disposal) was expected to be much larger by orders of magnitude than any metal loadings from creeks with elevated metal levels due to acid generation and increased solubilization of metals (Clarke, 1980). Steward (1972) did suggest that leachates, from open pit areas and tailings impoundments, entering creeks draining into Buttle Lake could contribute significantly to metal loadings to the lake, but elevated metal levels in Myra Creek did not become a major concern until 1980.

B.C. Research (1980) indicated that "...sources additional to the mine tailings seemed necessary to explain observed zinc concentrations in Buttle Lake." Clarke (1980) reassessed post-1972 Ministry of Environment data, identified statistical trends in heavy metal concentrations in Buttle Lake and recommended a multi-disciplinary investigation to evaluate the environmental impact of the Western mines operation in detail, including contamination of creek waters.

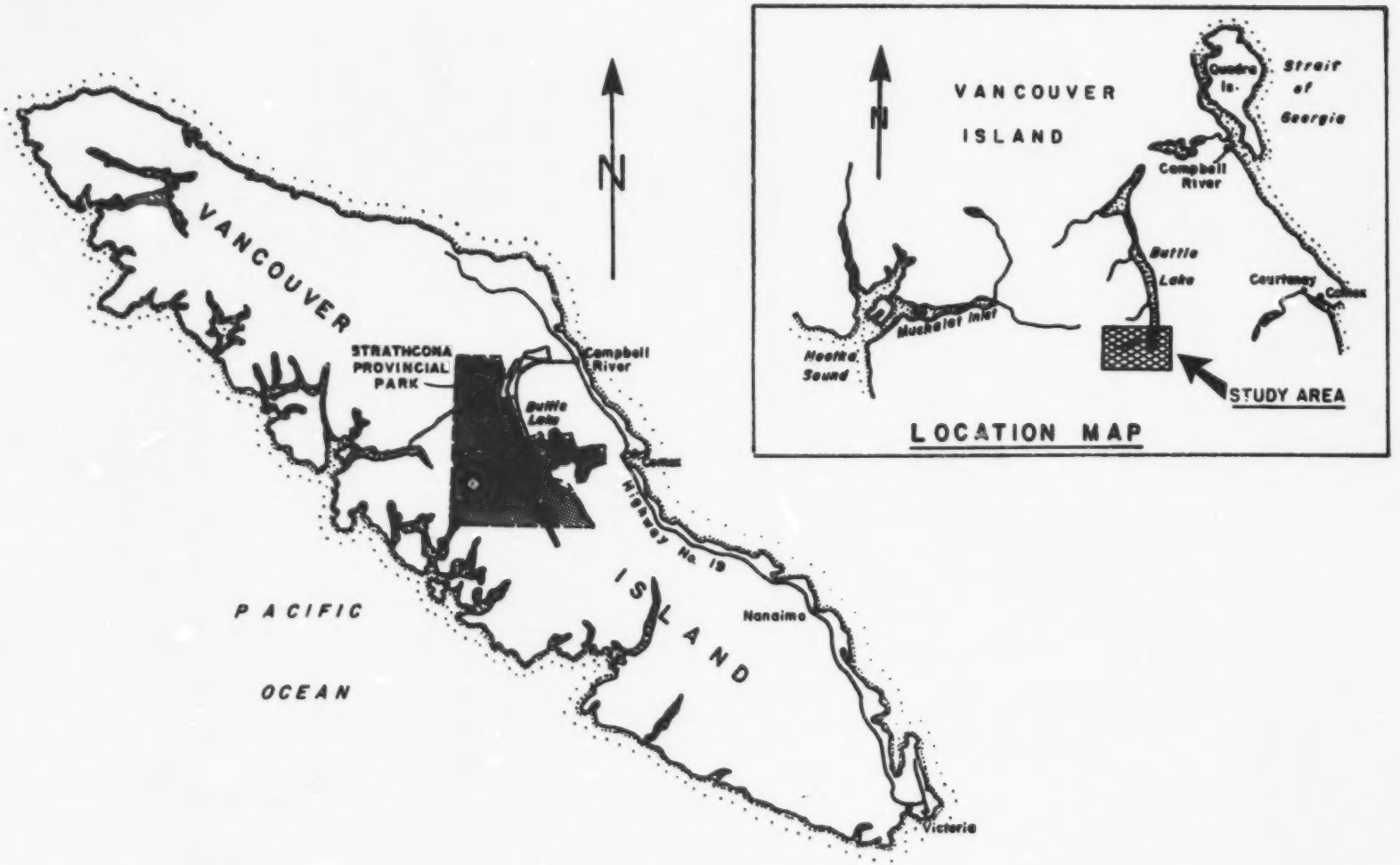

FIGURE 1 LOCATION OF WESTMIN RESOURCES LTD. MINING OPERATION

In 1981, as a result of the Clarke (1980) report, Westmin Resources Ltd. conducted a water quality monitoring program at their mining site. The results of the program indicated that microbiological leaching of zinc and copper in the Lynx open pit high pyrite waste rock dump had contaminated surface waters draining into Myra Creek (B.C. Research 1981). By August 1982, Westmin Resources Ltd. had installed a collection system between the waste rock dumps and Myra Creek to intercept surface and subsurface waters. This water was to be pumped to the new Myra integrated water management system for treatment before returning to Myra Creek.

The integrated surface and groundwater collection and treatment system began operating in early September 1982. Shortly afterwards, the Environmental Protection Service conducted a water quality monitoring program on December 7, 1982 to assess the effectiveness of the new collection and treatment system on improving the water quality in Myra Creek. The data collected on December 7, 1982 showed that there was still a significant metal loading to Myra Creek (Kelso and Jones, 1983).

Since the initial installation and trial run of the collection and treatment works, Westmin Resources Ltd. has been modifying the system to improve overall performance. The Environmental Protection Service conducted this water quality monitoring program in May 1983 to determine whether the continued modifications to the collection and treatment works had resulted in an improvement in the water quality of Myra Creek.

2. MATERIAL AND METHODS

On May 16, 1983, conductivity and temperature were recorded in transects across Myra Creek with a Hydrolab digital 4041 indicator unit and 4021 sonde unit at sites above and below the Westmin treatment and collection works (Figure 2). The results of this initial conductivity survey were then used to determine water chemistry sampling sites (Figure 3).

Water chemistry data were collected from May 17 to May 19 inclusive. Each site was sampled in the morning and afternoon in order to determine if pollutant concentrations varied during the day. For three days, morning and afternoon, at each of the seven water chemistry sampling sites, conductivity and temperature were recorded with the Hydrolab unit and field pH was recorded with a Metrohm pH meter, Model E588. Replicated grab samples were collected using a modified version of a replicated grab sampler reported by Oguss and Erlebach (1976). Six one liter samples were collected simultaneously at each site and three of those were individually analyzed for conductivity, turbidity, residues and sulphates. Each of the remaining three 1 liter bottles were used to fill two 250 ml bottles - one 250 ml sample was analyzed for total metals and the other was analyzed for dissolved metals.

The conductivity, turbidity, residues and sulphate samples were kept cool with wet ice until analyzed. Total metal samples of 250 ml each were preserved on site with one ml of nitric acid. Dissolved metal samples of 100 ml each were filtered on site through a 0.45 micron cellulose nitrate filter and then preserved with 0.5 ml nitric acid. All samples were delivered to the Environmental Protection Service/Department of Fisheries and Oceans Laboratory in West Vancouver by May 20, 1983.

For analytical methods refer to the Environment Canada Pacific Region Environmental Laboratory Manual (Anon, 1979). Laboratory conductivity results are reported in Appendix II and served only as an

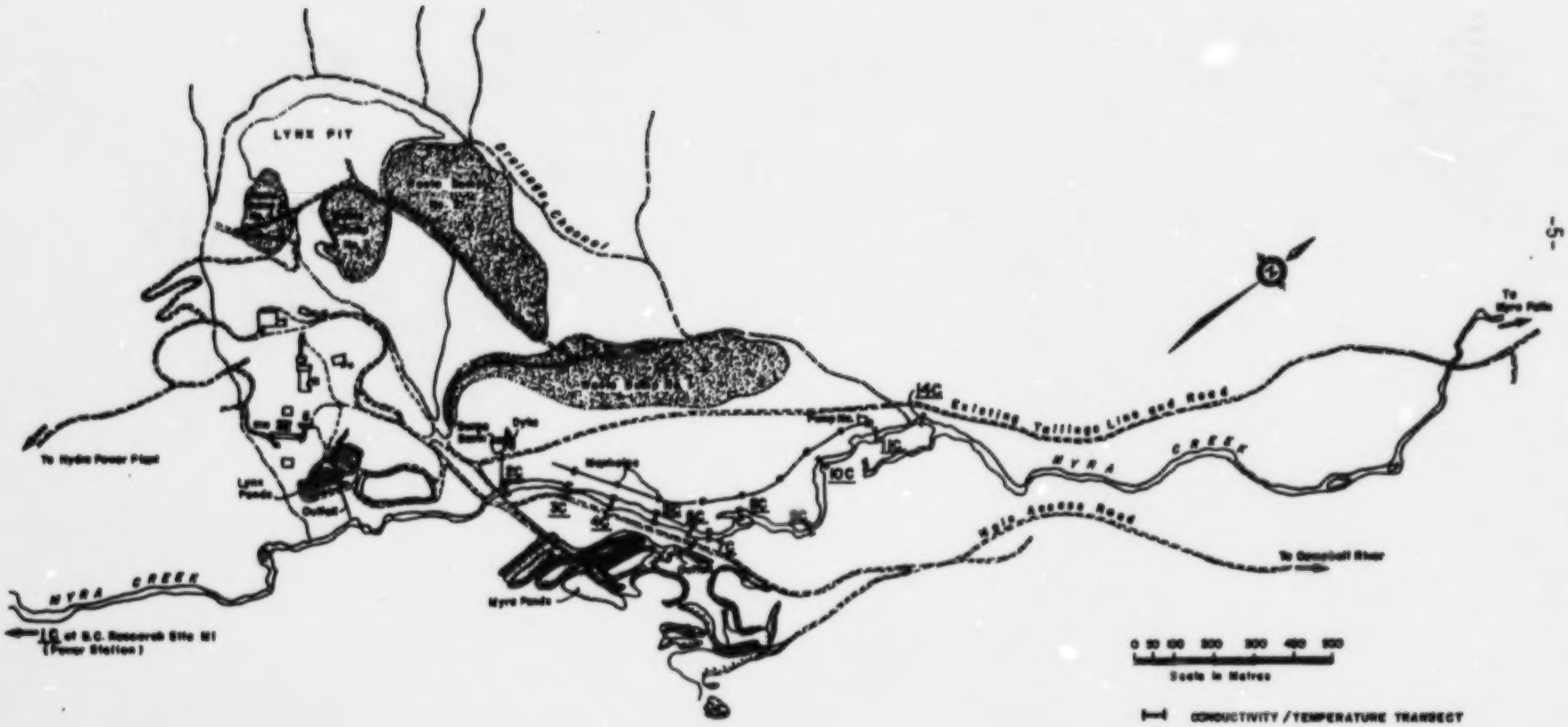

FIGURE 2 LOCATION OF CONDUCTIVITY / TEMPERATURE TRANSECTS IN MYRA CREEK - May 16, 1983

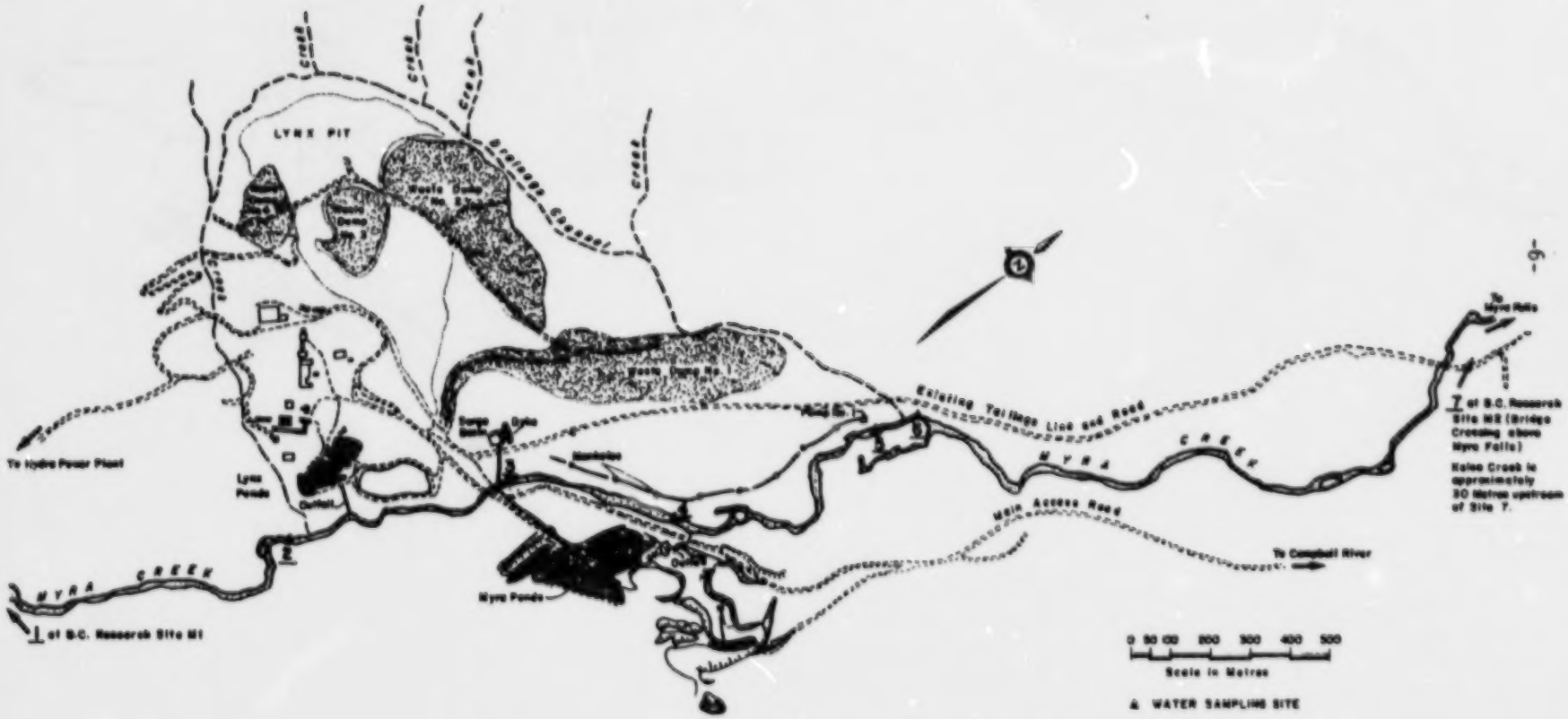

FIGURE 3 LOCATION OF WATER SAMPLING SITES IN MYRA CREEK - May 17 to May 19, 1983

instrument check for the Hydrolab unit. The Inductively Coupled Argon Plasma or ICAP scan, an automated atomic emissions spectrophotometer, was used for the total and dissolved metal analysis and gave a reading of twenty-six metals. If the copper, lead or cadmium readings were below the ICAP detection limit, the samples were rerun on the graphite furnace of the atomic absorption spectrophotometer to obtain a lower detection limit.

On May 16, a Sirco model #MK-V57 sampler was installed at site M2 for a trial run. From May 17 to May 19 inclusive, the sampler was set each morning to collect one sample per hour over a 24-hour period. On May 17, the Sirco sampler only collected samples for the first three consecutive hours, 9:00 to 11:00 inclusive, because of battery failure. Those samples were combined and analyzed for total metals. On May 18 and 19, samples from three consecutive hours were combined, mixed and then split to provide three replicate samples for total metal analysis.

On May 17, a replicated grab sample was collected from Kelso Creek, a stream of runoff from the tailings road that empties into Myra Creek approximately thirty meters upstream of M2. Replicate grab samples were collected along the south bank at site 9C, (one of the initial conductivity transects), on May 18 and along the south bank of water sampling site #4 on May 19 to determine if higher recorded conductivities at these sites could be attributed to any particular chemical parameter.

Replicated grab samples were collected from the Campbell River at the Gold River Rridge and from the Campbell River in Elk Falls Provincial Park on May 19, 1983 (Figure 4).

Intergravel sediments were collected at M1 and M2 on May 19, 1983 with a modified stainless steel syringe sampler (Derksen, 1983). Two syringe samples made up one replicate and three replicate samples were taken from each site. Samples were evacuated into 2-litre polyethylene sample bottles.

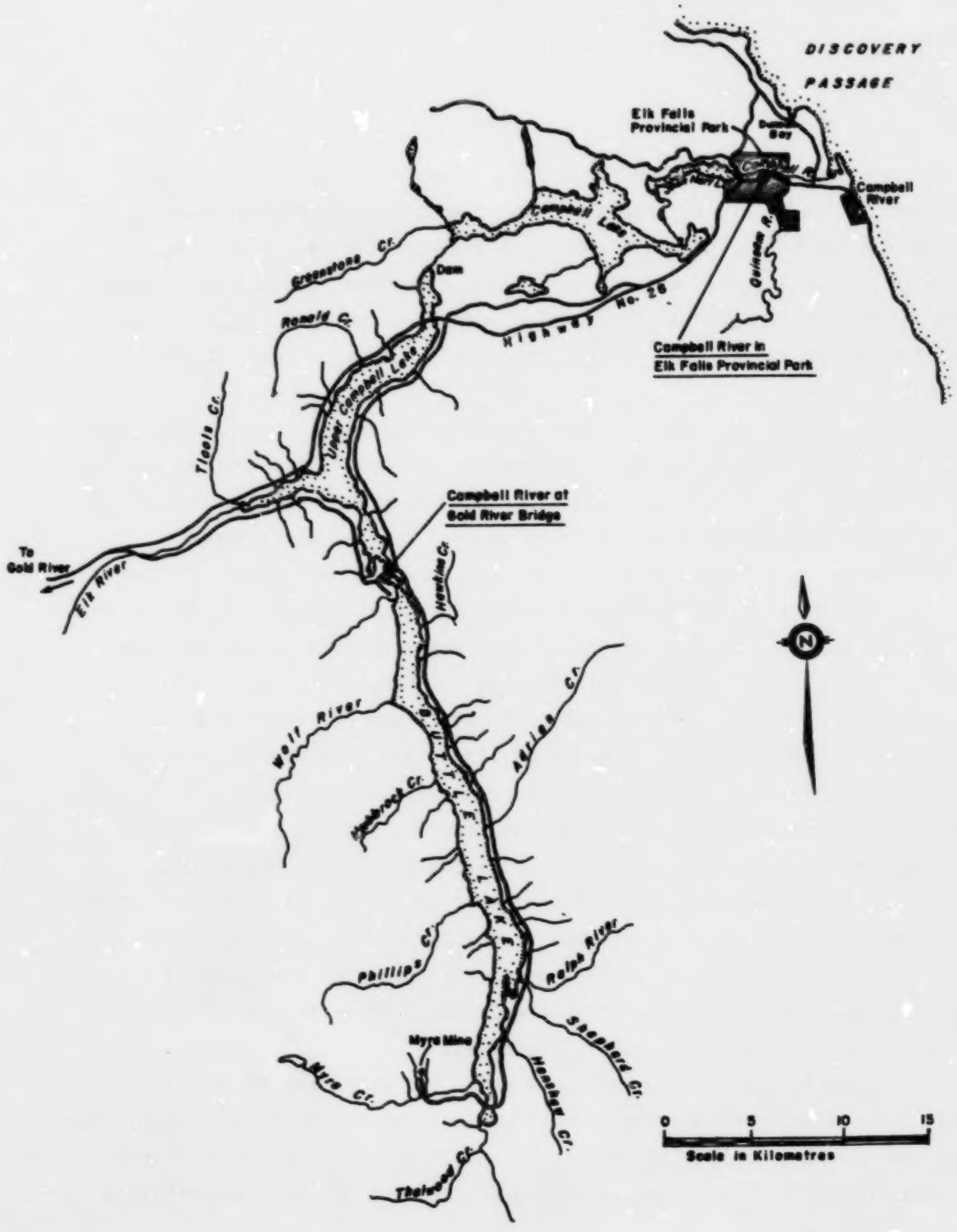

FIGURE 4 LOCATION OF CAMPBELL RIVER SITES

Using Imhoff cones, the original sample was settled for one hour to obtain a final sample. The total volume of the supernatant as well as the volume of settled material was recorded. The water in the cone was decanted and then the sediment was drained into a soil-bag by inverting the cone, pulling the plug, and then using distilled water to rinse any residual sediment into the sample bag. Each replicate sample was sieved to the < .15 mm fraction for metal analysis (Anon, 1979) at the EPS Laboratory. The percent of the total sample < .15 mm and $\geq$ .15 mm was also determined. See Appendix I for the results.

3. RESULTS AND DISCUSSION

3.1 Initial Conductivity/Temperature Survey - May 16, 1983

On May 16, 1983, a significant increase in conductivity was not noted until station 8C (150 meters downstream of the Myra ponds discharge) (Table 1). Conductivity increased: by only approximately 5 uS/cm from 1C (pool site approximately 100 meters downstream of M1) to 7C (25 meters downstream of Myra ponds discharge); by approximately 20 uS/cm from 7C to 8C; by only 6 uS/cm between 8C and 14C (25 meters downstream of diversion ditches).

Two anomalies existed within the general trend as just outlined. Conductivity was high on the south bank of 6C (64 uS/cm) above the Myra ponds discharge and in a pool area on the south shore of 9C (105 uS/cm). Water samples were collected at both of these sites to determine if these higher conductivities could be attributed to any particular chemical parameter (Sections 3.3.1 and 3.3.2).

Discharge from the diversion ditches had a high conductivity (97 uS/cm) and may have been responsible for the higher conductivity noted along the north shore of site 14C (25 meters downstream of the diversion ditches).

The Hydrolab proved to be a useful tool in determining variation not only between sites but within sites. Possible seepage from Myra ponds and some acid mine drainage along the south bank of site 6C and 9C respectively, may have gone undetected (Section 3.3) if, as in past surveys, only a replicate grab sample had been collected at center stream for predetermined stations.

3.2 Water Chemistry Study - May 17-19, 1983

3.2.1 Conductivity. Trends in conductivity readings along Myra Creek were important in determining the dispersion of effluent discharges in Myra Creek even though conductivities were low (Table 2). Conductivity

TABLE 1 CONDUCTIVITY (uS/cm) AND TEMPERATURE (°C) READINGS IN MYRA CREEK ON MAY 16, 1983

STATIONS													
1C		2C[1]		3C		4C		5C		6C[2]		7C	
Pool Site 100 meters downstream Mt surface to bottom		Below Lynx Pond at overhead pipeline crossing (north shore to south shore)		Above Myra Ponds Discharge beginning approx. 200 m downstream of 2C, spaced at 100 m intervals, (north shore to south shore)								Approx. 25 m downstream of Myra Ponds discharge (north to south shore)	
Cond.	Temp.	Cond.	Temp.	Cond.	Temp.	Cond.	Temp.	Cond.	Temp.	Cond.	Temp.	Cond.	Temp.
								35	6.3				
32	5.7	35	6.2			33	6.6	34	6.2	35	6.3		
31	5.7	37	6.0	32	6.2	33	6.2	32	6.2	34	6.3	36	6.4
28	5.6	31	6.0	32	6.1	33	6.2	32	6.2	35	6.2	33	6.3
		32	6.0	29	6.2	27	6.1	31	6.2	36	6.2	33	6.3
		36	6.0			28	6.1	32	6.2	64	6.2	39	6.3
								37	6.2				
$\bar{x}$ = 30		$\bar{x}$ = 34		$\bar{x}$ = 31		$\bar{x}$ = 31		$\bar{x}$ = 33		$\bar{x}$ = 35		$\bar{x}$ = 35	

STATIONS													
8C		9C		10C		11[3]		12C		13C		14C[4]	
Approx. 150 meters downstream Myra Pond discharge (north to south shore)		Band in Creek at powerline crossing to pumphouse (north to south shore)		200 m downstream of 9C		Pumphouse No. 1		Diversion Ditch Culvert 1		Diversion Culvert 2		25 metres downstream of diversion ditches	
Cond.	Temp.	Cond.	Temp.	Cond.	Temp.	Cond.	Temp.	Cond.	Temp.	Cond.	Temp.	Cond.	Temp.
		59	6.4	60	6.4	60	6.6					67	7.1
60	6.3	58	6.4	58	6.4	59	6.5					63	6.8
54	6.3	57	6.4	58	6.4	59	6.4	97	8.7	97	8.7	60	6.5
53	6.3	57	6.4	58	6.4	59	6.4					60	6.5
		58	6.4	59	6.4	59	6.4					60	6.5
		106	7.0									59	6.5
$\bar{x}$ = 56		$\bar{x}$ = 58		$\bar{x}$ = 59		$\bar{x}$ = 59						$\bar{x}$ = 62	

[1]Water Sampling Site #3
[2]Water Sampling Site #4
[3]Water Sampling Site #5
[4]Water Sampling Site #6

TABLE 2 MEAN FIELD CONDUCTIVITY (uS/cm) AND TEMPERATURE (°C) READINGS ACROSS SEVEN MYRA CREEK SITES FROM NORTH SHORE TO SOUTH SHORE - MAY 17 to MAY 19, 1983

MAY 17, 1983

	STATIONS													
	1 M1		2* Above Lynx Pond		3 Below Lynx Pond		4 Above Myra Pond Discharge		5 Pumphouse		6 Below Diversion		7 M2	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Time	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
							41	4.3						
					48	4.0	40	4.1			90	4.6		
			26	11.2	44	3.9	41	4.1	79	4.2	79	4.2		
	21	3.7	31	8.4	40	3.9	41	4.1	77	4.1	78	4.1	84	4.0
			26	8.0	40	3.9	41	4.1	76	4.1	77	4.1		
					41	3.9	43	4.1			77	4.1		
							77	4.2						
$\bar{x}$	21		28		43		41**		77		80		84	
Time	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
							46	5.0						
					48	4.9	43	4.9	85	5.2	93	5.8		
			15	7.6	44	4.8	44	4.8	85	5.1	86	5.3		
	21	4.5	26	7.3	41	4.8	44	4.8	85	5.0	85	5.2	86	4.8
			17	7.0	41	4.8	46	4.8	85	5.0	85	5.1		
					42	4.9	43	4.8	85	5.0	84	5.1		
							53	4.8	85	5.0	84	5.1		
							102	4.9						
$\bar{x}$	21		19		43		46**		85		86		86	

A = Field Conductivity North to South
B = Temperature North to South

Continued...

*Hydrolab was not brought to the site. Field conductivity was recorded on three replicated water samples.
**Not including elevated conductivity value from the south bank.

TABLE 2
(Continued)

MAY 18, 1983

	STATIONS													
	1 M1		2* Above Lynx Pond		3 Below Lynx Pond		4 Above Myra Pond Discharge		5 Pumphouse		6 Below Diversion		7 M2	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Time	10:00		10:00		10:25		12:30		11:30		12:00		9:00	
					46	3.8	44	5.0	78	4.4	83	5.2		
			26	7.5	44	3.6	41	4.9	78	4.3	78	4.7		
	18	3.2	27	7.0	36	3.6	41	4.8	77	4.3	79	4.6	92	3.8
			25	6.7	38	3.6	41	4.8	76	4.3	78	4.6		
					38	3.6	70	4.9	76	4.3	78	4.6		
$\bar{x}$	18		26		40		42**		77		79		92	
Time	14:45		14:45		15:15		17:45		16:25		16:35		13:45	
					49	6.4	47	6.3	73	6.8	79	6.8		
			20	7.6	45	6.0	44	6.2	72	6.4	71	6.4		
	18	5.7	23	11.3	41	5.8	44	6.2	72	6.4	70	6.4	92	5.8
			25	12.0	41	5.8	45	6.1	73	6.4	70	6.3		
					42	5.9	68	6.1	70	6.4	70	6.3		
$\bar{x}$	18		22		44		44**		72		72		92	

A = Field Conductivity North to South

B = Temperature North to South

*Hydrolab was not brought to the site. Field conductivity was recorded on three replicated water samples.

**Not including elevated conductivity value from the south bank.

Continued...

TABLE 2
(Continued)

MAY 19, 1983

	STATIONS													
	1 M1		2* Above Lynx Pond		3 Below Lynx Pond		4 Above Myra Pond Discharge		5 Pumphouse		6 Below Diversion		7 M2	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Time	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
					43	4.5	39	5.3	78	5.0	86	5.8		
			26	8.4	38	4.4	36	5.2	76	4.9	75	5.1		
	18	4.1	34	8.4	36	4.3	36	5.1	77	4.9	74	5.0	88	4.3
			35	8.3	35	4.3	37	5.1	76	4.9	74	5.0		
					36	4.3	140	5.3	76	4.9	74	5.0		
							156	5.5						
$\bar{x}$	18		32		38		37**		77		77		88	
Time	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
					32	6.4	23	6.8	51	6.7	54	7.6		
			30	13.8	30	6.0	21	6.7	47	6.5	47	6.6		
	16	5.9	26	13.5	25	5.9	17	6.6	48	6.4	42	6.6	86	6.1
			23	13.3	23	5.9	16	6.6	48	6.4	43	6.5		
					28	5.9	27	6.6	48	6.4	41	6.5		
$\bar{x}$	16		26		28		21		48		45		86	

A = Field Conductivity North to South

B = Temperature North to South

*Hydrolab was not brought to the site. Field conductivity was recorded on three replicated water samples.

**Not including elevated conductivity values from the south bank.

readings recorded on May 17th and May 18th were different from the pattern outlined by conductivity readings on May 16th, and increased noticeably below the Lynx as well as the Myra treatment system discharges: by 15 uS/cm from site #2 (control above Lynx pond) to site #3 (below the Lynx pond); by 35 uS/cm from site #4 (above Myra ponds) to site #5 (pumphouse below Myra ponds). On the morning of May 17th, conductivity increased only slightly (4 uS/cm) from site #6 (below the diversion ditches) to site #7 (M2). However, on May 18th the average conductivity increased noticeably from sites #6 to #7 (14 uS/cm in the morning; 20 uS/cm in the afternoon).

On May 19th, conductivity readings at two control sites differed. On the average, conductivity at site #2 was 10 to 14 uS/cm higher than at site #1. As such, the difference between the conductivity at site #2 and #3 was negligible. However, the increase in conductivity between sites #1 and #3 on the 19th was comparable to the increase in conductivity noted between sites #2 and #3 on the 17th and 18th. On the 19th, conductivity increased between sites #4 and #5, (40 uS/cm in the morning; 27 uS/cm in the afternoon) and between site #6 to #7, (11 uS/cm in the morning; 41 uS/cm in the afternoon).

Until the afternoon of May 19th, conductivities were comparatively high along the south bank of site #4, where levels ranged from 68 to 156 uS/cm, and were anywhere from 24 to 120 uS/cm greater than mid-stream conductivity values.

Conductivity on the north bank of site #6 (below the diversion ditches) was on the average 10 uS/cm higher than mid-stream.

Conductivity values recorded on this survey at control site M1 were comparable with conductivities recorded in December 1982 whereas conductivity values recorded at sites downstream of M1 were half as high as the December 1982 readings (Kelso and Jones, 1983).

3.2.2 Temperature. Temperatures were generally 2 to 2.5°C warmer in May 1983 than those reported by Kelso and Jones (1983) in December 1982 (Table 2).

3.2.3 Turbidity. Turbidity values in May 1983 were less than 0.1 mg/l and were comparable with values recorded by Kelso and Jones (1983) in December 1982.

3.2.4 Residues. Like conductivity, residues were very low but trends in levels rather than absolute values were considered more important in determing the effects of the mine's operation. In most instances, filterable (dissolved residue) made up the major portion if not all of the total residues (Table 3). Mean total residue ranged from 13 to 21 mg/l at site #1 to between 35 and 45 mg/l at site #7.

Residue increased most noticeably, by approximately 10 mg/l, between sites #4 and #5. A more gradual increase of 10 mg/l in total residue was noted from site #1 through to site #4. Total residue did not increase between sites #6 and #7.

Residue concentrations at M1 and below the Lynx pond discharge were comparable with the December 1982 survey results. Concentrations at the pumphouse in May 1983 were only half as high as residues recorded in December 1982 (Kelso and Jones, 1983). Concentrations at M2 in May 1983 were one third as high as residues recorded in December 1982.

3.2.5 Sulphates. Sulphate levels in Myra Creek were low but trends in sulphate values were useful in determing the effect of the Lynx and Myra ponds discharge on Myra Creek (Table 4). On each of the three days, morning and afternoon sampling showed a twofold increase in sulphate levels at site #3 (below the Lynx pond discharge) as compared to the control sites. There was another two- to threefold increase in sulphate levels from site #4 (above the Myra ponds discharge) to site #5 (pumphouse below Myra ponds discharge). Sulphate levels decreased slightly between site #5 and #6. Levels at site #7 (M2) were comparable to levels recorded at site #5.

The sulphate levels at M1 and below the Lynx Pond in May 1983 were comparable to levels recorded by Kelso and Jones (1983) in December

TABLE 3 MEAN RESIDUE CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 and 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS																				
	1 M1			2 Above Lynx Pond			3 Below Lynx Pond			4 Above Myra Ponds			5 Pumphouse			6 Below Diversion Ditches			7 M2		
	F.	NF.	T.	F.	NF.	T.	F.	NF.	T.	F.	NF.	T.	F.	NF.	T.	F.	NF.	T.	F.	NF.	T.
May 17, A.M.		10:20			13:30			10:45			12:40			11:35			12:00			9:00	
$\bar{x}$	17	< 5	17	15	5	19	22	< 5	24	25	< 5	25	35	< 5	35	39	< 5	39	33	5	37
s	2	0	2	3	2	1	2	1	2	1	0	1	1	0	1	3	0	3	4	2	2
May 17, P.M.		15:05			17:50			15:33			15:55			16:45			17:20			14:00	
$\bar{x}$	7	5	13	17	< 5	17	21	6	27	27	5	31	34	< 5	34	38	< 5	38	34	6	40
s	4	1	3	3	0	3	4	1	4	3	2	2	4	0	4	3	0	3	1	1	2
May 18, A.M.		10:00			10:00			10:25			12:30			11:30			12:00			9:00	
$\bar{x}$	14	< 5	14	15	< 5	21	20	7	25	26	< 5	27	35	< 5	35	40	< 5	42	35	< 5	35
s	3	0	3	3	0	4	9	7	0	5	0	3	1	0	2	3	0	2	10	0	10
May 18, P.M.		14:45			14:45			15:15			17:45			16:25			16:35			13:45	
$\bar{x}$	20	< 5	20	21	< 5	23	25	< 5	27	24	< 5	26	41	< 5	43	43	5	48	40	5	44
s	2	0	2	2	0	1	2	0	3	4	0	3	2	0	2	2	2	0	2	2	1
May 19, A.M.		9:55			10:00			10:35			12:20			11:35			11:45			8:50	
$\bar{x}$	15	< 5	19	2	< 5	25	22	< 5	24	27	< 5	28	36	< 5	36	38	< 5	39	40	< 5	43
s	2	1	3	2	0	2	1	0	1	5	0	5	3	0	4	1	0	2	2	0	2
May 19, P.M.		14:00			14:00			14:10			15:40			15:00			15:20			13:00	
$\bar{x}$	19	< 5	21	24	< 5	26	26	< 5	26	26	< 5	26	35	< 5	35	40	< 5	40	43	< 5	45
s	2	0	0	4	0	2	2	0	1	1	0	1	1	0	1	0	0	0	4	3	1
Overall																					
$\bar{x}$	15	< 5	17	17	< 5	21	23	< 5	25	26	14	27	36	< 5	36	40	< 5	41	37	< 5	40
s	5	1	4	4	1	4	4	3	3	3	12	3	3	0	4	2	< 5	4	6	< 5	5

F. = Filterable NF. = Non-Filterable

T. = Total s = Standard Deviation

Note: To calculate mean and standard deviation, one half the detection limit (2.5 mg/l) was used when sample concentrations were less than the detection limit (< 5 mg/l).

TABLE 4 MEAN SULPHATE CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS						
	1 M1	2 Above Lynx Pond	3 Below Lynx Pond	4 Above Myra Ponds Discharge	5 Pumphouse	6 Below Diversion Ditches	7 M2
May 17, A.M.	10:20	13:30	10:45	12:40	11:35	12:00	9:00
$\bar{x}$	2.6	1.9	5.3	4.1	11.5	9.2	12.1
s	0.3	0.2	0.1	0.1	0.1	0.7	0.2
May 17, P.M.	15:05	17:50	15:33	15:55	16:45	17:20	14:00
$\bar{x}$	2.1	2.3	4.9	4.4	11.2	10.5	11.4
s	0.1	0.2	0.2	0.2	0	0.9	0.2
May 18, A.M.	10:00	10:00	10:25	12:30	11:30	12:00	9:00
$\bar{x}$	2.2	2.3	4.5	4.5	11.3	9.9	11.9
s	0.1	0.2	0.3	0.2	0.1	0.1	0.6
May 18, P.M.	14:45	14:45	15:15	17:45	16:25	16:35	13:45
$\bar{x}$	2.4	2.6	5.1	4.9	11.8	10.5	12.4
s	0.2	0.2	0.1	0.2	0.1	0.1	0.4
May 19, A.M.	9:55	10:00	10:35	12:20	11:35	11:45	8:50
$\bar{x}$	2.8	2.3	4.5	4.4	11.4	9.6	12.5
s	0.4	0.1	0.1	0.1	0.4	0.1	0.3
May 19, P.M.	14:00	14:00	14:10	15:40	15:00	15:20	13:00
$\bar{x}$	2.5	2.5	4.2	4.2	10.0	8.7	11.9
s	0.1	0	0.2	0.1	0.1	0.1	0.1
Overall							
$\bar{x}$	2.4	2.3	4.8	4.4	11.2	9.7	12.0
s	0.3	0.3	0.4	0.3	0.6	0.8	0.4

s = Standard Deviation

1982. Sulphate levels at M2 were only one-third as high as levels recorded in December 1982.

3.2.6 pH. The pH was slightly acidic to neutral (Table 5): the lowest pH (6.23) was recorded on May 17 at site #7 (M2); the highest pH (7.10) was recorded on May 18 at site #6 (pumphouse). The pH in Myra Creek appeared relatively unaffected by mining activity.

3.2.7 Hardness. The variability in the hardness data was high and in instances, there was no measure of salts or divalent metallic cations (Table 6). Some samples indicated an approximate threefold increase in hardness from M1 to M2. However, at what point significant increases in hardness occurred may not be accurately determined from the data because of the high variability.

3.2.8 Copper. At the two control sites, (#1 and #2), total copper ranged from less than 0.001 to 0.002 mg/l, with the exception of results from the afternoon of May 18. Two replicated samples collected the afternoon of May 18 had total copper values of 0.004 mg/l. These higher concentrations appear to be anomalous and the samples may have been contaminated. Dissolved copper at sites 1 and 2 was always less than 0.001 mg/l (Table 7). Below the mine site, mean total and dissolved copper concentrations ranged from 0.002 mg/l to 0.006 mg/l. In all cases, total copper was mainly made up of the dissolved fraction.

Copper concentrations increased most noticeably below the Lynx pond discharge (site #3) and did not increase again immediately below the influence of the Myra ponds discharge (sites #5 and #6). Another significant increase in copper concentrations was noted at M2 (site #7). All copper concentrations recorded below the control sites exceeded those at the control sites.

By sampling in the morning and afternoon over three consecutive days, variation in concentrations between sites, between days and within

TABLE 5 MEAN FIELD pH (relative units) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS						
	1	2	3	4	5	6	7
	M1	Above Lynx Pond	Below Lynx Pond	Above Myra Ponds Discharge	Pumphouse	Below Diversion Ditches	M2
May 17, A.M.	10:20	13:30	10:45	12:40	11:35	12:00	9:00
$\bar{x}$	6.74	6.87	6.53	6.66	6.96	6.86	6.23
May 17, P.M.	15:06	17:50	15:33	15:55	16:45	17:20	14:00
$\bar{x}$	6.90	6.86	6.60	6.89	6.80	6.93	6.91
May 18, A.M.	10:00	10:00	10:25	12:30	11:30	12:00	9:00
$\bar{x}$	6.78	6.72	6.88	6.86	6.59	7.10	6.76
May 18, P.M.	14:45	14:45	15:15	17:45	16:25	16:35	13:45
$\bar{x}$	6.79	6.74	6.89	6.78	6.66	6.89	6.65
May 19, A.M.	9:55	10:00	10:35	12:20	11:35	11:45	8:50
$\bar{x}$	6.70	6.72	6.35	6.48	6.73	6.89	6.53
May 19, P.M.	14:00	14:00	14:10	15:40	15:00	15:20	13:00
$\bar{x}$	6.73	6.85	6.70	6.70	6.71	6.89	6.79
Overall							
$\bar{x}$	6.77	6.79	6.61	6.71	6.74	6.92	6.58

*Note: $\bar{x} = \log_{10} \dfrac{1}{\dfrac{\frac{1}{10^{pH1}} + \frac{1}{10^{pH2}} + \frac{1}{10^{pH3}}}{n}}$

TABLE 6 MEAN HARDNESS CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS													
	1 M1		2 Above Lynx Pond		3 Below Lynx Pond		4 Above Myra Ponds Discharge		5 Pumphouse		6 Below Diversion Ditches		7 M2	
	Ca,Mg	Total	Ca,Mg	Total	Ca,Mg	Total	Ca,Mg	Total	Ca,Mg	Total	Ca,Mg	Total	Ca,Mg	Total
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
$\bar{x}$	8.31	8.60	10.63	10.90	13.87	14.20	13.57	13.83	21.00	21.37	24.83	25.13	22.70	23.10
s	0.11	0.15	0.23	0.26	0.23	0.26	0.12	0.12	0.17	0.21	0.42	0.42	0.17	0.17
May 17, P.M.	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
$\bar{x}$	8.56	8.84	-	-	14.03	14.37	13.87	14.17	10.08	10.08	12.23	12.20	23.70	24.13
s	0.05	0.03	-	-	0.12	0.15	0.12	0.12	1.26	1.25	0.25	0.26	0.10	0.06
May 18, A.M.	10:00		10:00		10:25		12:30*		11:30		12:00**		9:00**	
$\bar{x}$	-	-	-	-	-	-	1.46	1.37	-	-	2.44	2.35	11.45	11.65
s	-	-	-	-	-	-	-	-	-	-	0.02	0.01	0.64	0.64
May 18, P.M.	14:45*		14:45		15:15		17:45		16:25		16:35		13:45**	
$\bar{x}$	7.50	7.57	-	-	-	-	5.53	5.57	10.85	10.85	11.63	11.64	5.45	5.57
s	-	-	-	-	-	-	5.60	5.48	0.07	0.05	1.96	1.93	2.47	2.41
May 19, A.M.	9:55*		10:00*		10:35**		12:20		11:35**		11:45		8:50**	
$\bar{x}$	11.50	11.70	0.03	0.04	0.21	0.88	8.58	8.66	7.33	7.34	9.70	9.71	8.91	9.03
s	-	-	-	-	0.04	0.11	6.96	7.01	1.24	1.25	1.36	1.33	0.01	0
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
$\bar{x}$	7.45	7.72	10.63	10.87	10.93	11.27	11.87	12.17	17.57	17.83	23.03	23.30	22.87	23.27
s	0.03	0.06	0.58	0.64	0.06	0.12	0.06	0.06	0.65	0.70	0.81	0.87	0.68	0.68
Overall														
$\bar{x}$	8.36	8.61	9.12	9.33	10.63	11.02	10.11	10.28	14.02	14.17	14.66	14.74	17.29	17.60
s	1.15	1.15	4.02	4.11	5.33	5.20	5.11	5.20	5.37	5.53	7.71	7.86	7.56	7.70

s = Standard Deviation

*based on one sample rather than triplicate sample

**based on two samples rather than triplicate sample

TABLE 7 MEAN COPPER CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS													
	1 M1		2 200 m Above Lynx Pond		3 400 m Below Lynx Pond		4 50 m Above Myra Ponds Discharge		5 Pumphouse 700 m Below Myra Discharge		6 25 m Below Diversion Ditches		7 M2	
	T.	D.*	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
$\bar{x}$	< 0.001	< 0.001	< 0.001	< 0.001	0.004	0.003	0.003	0.002	0.002	0.002	0.003	0.002	0.005	0.005
s	0	0	< 0.001	0	0.002	< 0.001	0.001	0	0.001	0	0.001	0.001	0.001	0
May 17, P.M.	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
$\bar{x}$	< 0.001	< 0.001	< 0.001	< 0.001	0.003	0.002	0.003	0.002	0.004	0.002	0.004	0.002	0.005	0.003
s	< 0.001	< 0.001	0	0	0.001	0.001	0.001	0.001	0.001	0	0.002	0	0.001	0.001
May 18, A.M.	10:00		10:00		10:25		12:30		11:35		12:00		9:00	
$\bar{x}$	< 0.001	< 0.001	< 0.001	< 0.001	0.004	0.004	0.004	0.005	0.002	0.003	0.002	0.002	0.005	0.005
s	0	0	0	0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0	0.001
May 18, P.M.	14:45		14:45		15:15		17:45		16:25		16:35		13:45	
$\bar{x}$	0.003**	< 0.001	< 0.001	< 0.001	0.005	0.004	0.003	0.004	0.005	0.003	0.003	0.002	0.006	0.006
s	0.002	< 0.001	0	0	0.002	0.001	0	0.001	0.002	0	0	0.001	0.001	0
May 19, A.M.	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
$\bar{x}$	0.001	< 0.001	< 0.001	< 0.001	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.005	0.005
s	< 0.001	0	0	0	0.001	0	0.001	0.001	0.001	0	0.001	0	0.001	0.001
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
$\bar{x}$	< 0.001	< 0.001	< 0.001	< 0.001	0.005	0.003	0.003	0.002	0.002	0.002	0.003	0.002	0.006	0.004
s	0	0	0	0	0.002	0.001	0	0	0	0.001	0	0.001	0.001	0
Overall														
$\bar{x}$	0.001	< 0.001	< 0.001	< 0.001	0.004	0.003	0.003	0.003	0.003	0.002	0.003	0.002	0.005	0.005
s	0.001	< 0.001	< 0.001	0	0.001	0.001	< 0.001	0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	0.001

*T. = Total **Contamination of two of the triplicate samples was suspect

D. = Dissolved s = Standard Deviation

Note: To calculate mean and standard deviation, one half the detection limit (0.0005 mg/l) was used when sample concentrations were less than the detection limit (< 0.001 mg/l)

each day could be observed. Comparing only the means and standard deviat.ons, a difference in total copper concentrations between sites was noted. Concentrations at site #7 were elevated as compared to site #1. There also appeared to be some variation in total copper concentrations between sampling days at the sites below the two control sites.

Before determining whether there was a variation in concentrations within a day, that is between morning and afternoon samples, the morning total copper results were pooled and subjected to a Chi-square goodness of fit test to determine if the pooled results came from a normal distribution. The overall hypothesis was rejected with 99.9% confidence and indicated that the samples did not come from a normal distribution. Therefore, the non-parametric Mann-Whitney test rather than the parametric t-test was used to determine whether there was a significant difference between morning and afternoon samples. At the 95% confidence level, the null hypothesis was accepted and indicated that there was no significant difference between morning and afternoon total copper concentrations.

On the morning of May 17, a replicated grab sample from M2 was collected during the three hour period the Sirco composite sample was taken. The average grab sample total copper concentration was 0.005 mg/l whereas the Sirco composite total copper concentration was 0.009 mg/l (Table 8). The Sirco result was unusually high.

A replicated grab sample was colleced the morning of May 18th (total Cu, $\bar{x}$ = 0.005) during the time the 9:00-11:00 hour Sirco composite sample was collected (total Cu, $\bar{x}$ = 0.007). Another replicate grab sample was collected the afternoon of May 18 total Cu ($\bar{x}$ = 0.006) during the time the 12:00-14:00 hour Sirco composite sample was collected (total Cu, $\bar{x}$ = 0.008). The total copper concentrations from the Sirco composite samples on May 18th, exceeded the replicated grab sample concentrations. However, there was less of a difference between the grab and Sirco sample concentrations on the 18th compared to the 17th. By May 19, the total copper results from the replicated grab samples (morning $\bar{x}$ = 0.005 mg/l;

TABLE 8 MEAN TOTAL COPPER CONCENTRATIONS (mg/l) FROM SIRCO SAMPLES COLLECTED MAY 17 THROUGH TO MAY 20, 1983 AT SITE #7-M2

DATE	TIME	$\bar{x}$**	s
May 17	9:00 - 11:00	0.009*	
May 18	9:00 - 11:00	0.007	0
	12:00 - 14:00	0.008	0
	15:00 - 17:00	0.008	0
	18:00 - 20:00	0.007	0.001
	21:00 - 23:00	0.007	0.001
May 18-19	24:00 - 2:00	0.006	0.001
	3:00 - 5:00	0.006	0.001
	6:00 - 8:00	0.006	0
May 19	9:00 - 11:00	0.005	0.001
	12:00 - 14:00	0.005	0.001
	15:00 - 17:00	0.005	0
	18:00 - 20:00	0.006	0
	21:00 - 23:00	0.008	0
May 19-20	24:00 - 2:00	0.006	0
	3:00 - 5:00	0.006	0.001
	6:00 - 8:00	0.006	0.001

*On May 17, samples were collected for only the first three consecutive hours, 9:00 - 11:00 inclusive, were then combined and analyzed as one sample for total metals.

**On May 18 and 19, samples from three consecutive hours were combined, mixed and then split to provide three replicate samples for total metal analysis.

afternoon $\bar{x}$ = 0.006 mg/l) were comparable to the total copper results from the Sirco composite samples (9:00-11:00 hour composite $\bar{x}$ = 0.005 mg/l; 12:00-14:00 hour composite $\bar{x}$ = 0.005 mg/l). Possibly, the Sirco sampler was contaminated and did not fully flush until well into the second day.

Total copper results from the Sirco sampler at site #7 (M2) over a 24-hour period from 9:00 AM May 18 to 9:00 AM May 19, ranged from 0.006 to 0.008 mg/l. The maximum variation throughout the period was 0.002 mg/l (Table 8). Total copper concentrations from the Sirco composites at M2 from 9:00 AM May 19 to 9:00 AM May 20 ranged from 0.005 to 0.008 mg/l. The maximum variation throughout this period was 0.003 mg/l.

3.2.9 Zinc

At the two control sites, total zinc ranged from < 0.002 mg/l to 0.006 mg/l and dissolved zinc ranged from < 0.002 mg/l to 0.003 mg/l. Below the control sites, total zinc ranged from 0.054 mg/l at site #7 to 0.013 mg/l at site #4 and dissolved zinc ranged from < 0.002 mg/l at site #3 to 0.054 mg/l at site #7 (Table 9).

Zinc concentrations in Myra Creek followed the same trend as copper concentrations. The greatest increase in zinc concentrations was noted below the Lynx pond discharge (Site #3) where concentrations increased between five- and tenfold. There was no further significant increase in zinc below the Myra ponds discharge (sites #5 and #6). Another twofold increase in zinc concentrations was noted below M2 (site #7). All total zinc concentrations below the control sites exceeded levels recorded at the control sites (Table 9).

Comparing means and standard deviations, variation in total zinc concentrations between sites and variation in dissolved zinc concentrations between days was noted. The laboratory had difficulty digesting the samples before they were run on the ICAP scan. Therefore, some of the samples may not have been adequately digested before they were analyzed which might explain why dissolved zinc concentrations ranged from a mean of < 0.002 to 0.029 mg/l at one site (#3).

TABLE 9 MEAN ZINC CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS													
	1 M1		2 Above Lynx Pond		3 Below Lynx Pond		4 Above Myra Ponds Discharge		5 Pumphouse		6 Below Diversion Ditches		7 M2	
	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
$\bar{x}$	0.002	< 0.002	< 0.002	< 0.002	0.028	0.028	0.017	0.018	0.024	0.023	0.022	0.020	0.053	0.054
s	0.001	0	0	0	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0
May 17, P.M.	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
$\bar{x}$	0.003	0.003	< 0.002	< 0.002	0.029	0.029	0.017	0.018	0.029	< 0.002	0.030	< 0.002	0.054	0.052
s	0.004	0.003	0.001	0	0.002	0.002	0.002	0.001	0.002	0	0.010	0	0.002	0
May 18, A.M.	10:00		10:00		10:25		12:30		11:30		12:00		9:00	
$\bar{x}$	0.003	< 0.002	< 0.002	< 0.002	0.028	< 0.002	0.024	< 0.002	0.022	< 0.002	0.022	< 0.002	0.052	0.013
s	0.001	0	0	0	0.001	0	0.001	0	0.002	0	0.001	0	0.001	0.011
May 18, P.M.	14:45		14:45		15:15		17:45		16:25		16:35		13:45	
$\bar{x}$	0.006	< 0.002	< 0.002	< 0.002	0.032	0.002	0.022	0.011	0.026	0.009	0.024	0.010	0.054	0.024
s	0.002	0	0	0	0.003	0.001	0.001	0.001	0.003	0.007	0.001	0.001	0.001	0.022
May 19, A.M.	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
$\bar{x}$	0.004	< 0.002	< 0.002	< 0.002	0.031	0.011	0.024	0.013	0.021	0.004	0.020	0.005	0.049	0.021
s	0.006	0	0	0	0.003	0.009	0.001	0.008	0.001	0.003	0.001	0.002	0.001	0.017
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
$\bar{x}$	0.003	0.002	< 0.002	< 0.002	0.026	0.020	0.021	0.019	0.018	0.015	0.020	0.017	0.051	0.047
s	0.002	0.001	0	0	0.004	0.002	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002
Overall														
$\bar{x}$	0.003	< 0.002	< 0.002	< 0.002	0.029	0.015	0.021	0.014	0.024	0.009	0.023	0.009	0.052	0.035
s	0.003	0.001	0.002	0	0.003	0.012	0.003	0.007	0.004	0.009	0.005	0.008	0.002	0.020

T. = Total s = Standard Deviation

D. = Dissolved

Note: To calculate mean and standard deviation one half the detection limit (0.001 mg/l) was used when sample concentrations were less than the detection limit (< 0.002 mg/l).

To determine whether there was variation within a day, the morning and afternoon results from all seven sites over the three day sampling period were pooled and compared. First, the pooled morning total zinc concentrations were subjected to a Chi-square goodness of fit test to determine whether the concentrations came from a normal distribution. The null hypothesis was rejected with 99.9% confidence and indicated that the samples did not come from a normal distribution. Therefore, the non-parametric Mann-Whitney test rather than the parametric t-test was used to determine whether there was a significant difference between morning and afternoon samples. At the 95% confidence level, the null hypothesis was accepted and indicated that there was no significant difference between morning and afternoon total zinc concentrations.

On May 17 and 18 total zinc concentrations from the Sirco samples (Table 10) were slightly higher than the total zinc concentrations from the replicated grab samples (Table 9). On the morning of May 19, Sirco and grab sample total zinc concentrations were comparable.

Total zinc concentrations from the Sirco samples ranged from 0.04 to 0.057 mg/l for the 24-hour period beginning 9:00 AM May 18 and the maximum variation was 0.012 mg/l. Total zinc concentrations from the Sirco samples for the 24-hour period begining 9:00 AM May 19, ranged from 0.031 to 0.04 mg/l. The maximum variation in concentrations was 0.019 mg/l. The higher Sirco sample zinc concentrations and smaller daily variation in concentrations noted on May 18 as compared to May 19 may have been due to contamination as previously discussed.

3.2.10 Cadmium. Total and dissolved cadmium was equal to or less than 0.0005 mg/l at all sampling sites during the three day survey.

3.2.11 Lead. Lead levels in Myra Creek both above and below the mine/mill site were low (Table 11). The replicated grab samples mean total and dissolved lead concentrations never exceeded 0.001 mg/l. The

TABLE 10 MEAN TOTAL ZINC CONCENTRATIONS (mg/l) FROM SIRCO SAMPLES COLLECTED MAY 17 THROUGH TO MAY 20, 1983 AT SITE #7-M2

DATE	TIME		
May 17	9:00 - 11:00	0.056	*
		$\bar{x}$**	s
May 18	9:00 - 11:00	0.050	0.001
	12:00 - 14:00	0.050	0.001
	15:00 - 17:00	0.056	0
	18:00 - 20:00	0.057	0.001
	21:00 - 23:00	0.051	0.001
May 18-19	24:00 - 2:00	0.051	0.006
	3:00 - 5:00	0.046	0.001
	6:00 - 8:00	0.046	0
May 19	9:00 - 11:00	0.047	0.002
	12:00 - 14:00	0.045	0.001
	15:00 - 17:00	0.039	0
	18:00 - 20:00	0.036	0.001
	21:00 - 23:00	0.039	0.001
May 19-20	24:00 - 2:00	0.031	0.001
	3:00 - 5:00	0.034	0.002
	6:00 - 8:00	0.035	0.001

*On May 17, samples were collected for only the first three consecutive hours, 9:00 - 11:00 inclusive, were then combined and analyzed as one sample for total metals.

**On May 18 and 19, samples from three consecutive hours were combined, mixed and then split to provide three replicate samples for total metal analysis.

TABLE 11 MEAN LEAD CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS													
	1 M1		2 Above Lynx Pond		3 Below Lynx Pond		4 Above Myra Ponds Discharge		5 Pumphouse		6 Below Diversion Ditches		7 M2	
	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
$\bar{x}$	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
s	0	0	0.001	0	0.001	0	0	0	0.001	0	0	0	0	0
May 17, P.M.	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
$\bar{x}$	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001
s	0.001	0	0	0	0	0.001	0	0	0	0	0	0	0.001	0
May 18, A.M.	10:00		10:00		10:25		12:30		11:30		12:00		9:00	
$\bar{x}$	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
s	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0
May 18, P.M.	14:45		14:45		15:15		17:45		16:25		16:35		13:45	
$\bar{x}$	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
s	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0
May 19, A.M.	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
$\bar{x}$	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
s	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
$\bar{x}$	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001
s	< 0.001	0	0	0	0	0.001	0	0	0	0	0	0	0.001	0
Overall														
$\bar{x}$	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
s	< 0.001	0	< 0.001	0	< 0.001	< 0.001	0	0	< 0.001	0	0	0	< 0.001	0

T. = Total

D. = Dissolved

s = Standard Deviation

Note: To calculate mean and standard deviation one half the detection limit (0.0005 mg/l) was used when sample concentrations were less than the detection limit (< 0.001 mg/l)

highest average total lead concentration (0.003 mg/l) was recorded at M2 in a Sirco sample collected between 6:00 and 8:00 AM May 20 (Table 12).

3.2.12 Aluminum. At the control site #1, mean total aluminum ranged from < 0.05 to 0.08 mg/l and dissolved aluminum ranged from < 0.05 to 0.05 mg/l. At M2 (site #7), mean total aluminum ranged from 0.05 to 0.10 mg/l and dissolved aluminum ranged from < 0.05 to 0.05 mg/l (Table 13).

The highest average total aluminum concentration (0.14 mg/l) was recorded below the diversion ditches (site #6) on the afternoon of May 17. Average dissolved aluminum concentrations were equal to or below detection limit in all samples.

In all but one instance Sirco composite and replicated grab samples were comparable. On the afternoon of May 19, the average total aluminum concentration from the replicated grab sample was slightly higher than the total aluminum concentration from the Sirco composite samples (Table 14).

Mean total aluminum concentrations from Sirco composite samples collected during the 24-hour period beginning at 9:00 AM May 18 ranged from 0.05 to 0.07 mg/l. Maximum variation over the same 24 hour period was 0.06 mg/l. Mean total aluminum concentrations from Sirco composite samples collected during the 24-hour period beginning 9:00 AM May 19 at site #7 ranged from 0.05 to 0.13 mg/l. Maximum variation over the same 24-hour period was 0.13 mg/l.

3.2.13 Iron.

At control site #1 mean total iron ranged from < 0.005 to 0.024 mg/l and dissolved iron ranged from < 0.005 to 0.007 mg/l. At M2 (site #7) mean total iron ranged from 0.015 to 0.041 mg/l and dissolved iron ranged from < 0.005 to 0.010 mg/l (Table 15).

TABLE 12 MEAN TOTAL LEAD CONCENTRATIONS (mg/l) FROM SIRCO SAMPLES COLLECTED MAY 17 THROUGH TO MAY 20, 1983 AT SITE #7-M2

DATE	TIME	$\bar{x}$**	s
May 17	9:00 - 11:00	0.002	*
May 18	9:00 - 11:00	< 0.001	0
	12:00 - 14:00	0.001	0
	15:00 - 17:00	0.001	0.001
	18:00 - 20:00	< 0.001	0.001
	21:00 - 23:00	< 0.001	0.001
May 18-19	24:00 - 2:00	0.002	0.001
	3:00 - 5:00	0.001	0.001
	6:00 - 8:00	0.002	0
May 19	9:00 - 11:00	0.002	0.001
	12:00 - 14:00	0.002	0
	15:00 - 17:00	0.002	0
	18:00 - 20:00	0.002	0.001
	21:00 - 23:00	0.002	0.001
May 19-20	24:00 - 2:00	0.002	0.001
	3:00 - 5:00	0.002	0.001
	6:00 - 8:00	0.003	0.001

*On May 17, samples were collected for only the first three consecutive hours, 9:00 - 11:00 inclusive, were then combined and analyzed as one sample for total metals.

**On May 18 and 19, samples from three consecutive hours were combined, mixed and then split to provide three replicate samples for total metal analysis.

TABLE 13 MEAN ALUMINUM CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS													
	1 M1		2 Above Lynx Pond		3 Below Lynx Pond		4 Above Myra Ponds Discharge		5 Pumphouse		6 Below Diversion Ditches		7 M2	
	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
$\bar{x}$	0.05	0.05	< 0.05	< 0.05	0.07	< 0.05	< 0.05	< 0.05	0.05	< 0.05	< 0.05	< 0.05	0.05	0.05
s	0.02	0.02	0.03	0	0.01	0.02	0	0.01	0.02	0.01	0.01	0	0.02	0.01
May 17, P.M.	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
$\bar{x}$	0.08	< 0.05	0.07	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	0.14	< 0.05	0.08	0.05
s	0.08	0.02	0.01	0	0.02	0.02	0	0	0.01	0	0.06	0	0.01	0.01
May 18, A.M.	10:00		10:00		10:25		12:30		11:30		12:00		9:00	
$\bar{x}$	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.07	< 0.05
s	0	0	0	0	0	0	0.03	0	0	0	0	0	0.01	0
May 18, P.M.	14:45		14:45		15:15		17:45		16:25		16:35		13:45	
$\bar{x}$	< 0.05	< 0.05	< 0.05	< 0.05	0.07	< 0.05	< 0.05	< 0.05	0.07	< 0.05	0.05	< 0.05	0.08	< 0.05
s	0.01	0	0	0	0.01	0	0	0	0	0	0.03	0	0.02	0
May 19, A.M.	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
$\bar{x}$	0.07	< 0.05	0.07	< 0.05	0.09	< 0.05	0.08	< 0.05	0.07	< 0.05	0.07	< 0.05	0.06	< 0.05
s	0.01	0	0	0	0.01	0	0.01	0	0	0	0.01	0	0	0
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
$\bar{x}$	0.08	< 0.05	< 0.05	< 0.05	0.06	< 0.05	0.09	< 0.05	< 0.05	< 0.05	0.09	< 0.05	0.10	0.05
s	0.01	0.01	0	0	0.03	0	0.01	0.01	0.01	0	0.01	0	0.01	0.02
Overall														
$\bar{x}$	0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	0.05	0.07	< 0.05	0.07	< 0.05
s	< 0.05	< 0.05	< 0.05	0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0	< 0.05	< 0.05

T. = Total

D. = Dissolved

s = Standard Deviation

Note: To calculate mean and standard deviation one half the detection limit (0.025 mg/l) was used when sample concentrations were less than the detection limit (< 0.05 mg/l).

TABLE 14 MEAN TOTAL ALUMINUM CONCENTRATIONS (mg/l) FROM SIRCO SAMPLES COLLECTED MAY 17 THROUGH TO MAY 20, 1983 AT SITE #7-M2

DATE	TIME		
May 17	9:00 - 11:00	0.050	*
		$\bar{x}$**	s
May 18	9:00 - 11:00	0.05	0.02
	12:00 - 14:00	0.07	0.01
	15:00 - 17:00	0.07	0.01
	18:00 - 20:00	0.07	0
	21:00 - 23:00	0.06	0.02
May 18-19	24:00 - 2:00	0.07	0.01
	3:00 - 5:00	0.07	0.01
	6:00 - 8:00	0.07	0.02
May 19	9:00 - 11:00	0.05	0.02
	12:00 - 14:00	0.08	0
	15:00 - 17:00	0.08	0.01
	18:00 - 20:00	0.11	0.01
	21:00 - 23:00	0.13	0.03
May 19-20	24:00 - 2:00	0.11	0.02
	3:00 - 5:00	0.12	0
	6:00 - 8:00	0.12	0.04

*On May 17, samples were collected for only the first three consecutive hours, 9:00 - 11:00 inclusive, were then combined and analyzed as one sample for total metals.

**On May 18 and 19, samples from three consecutive hours were combined, mixed and then split to provide three replicate samples for total metal analysis.

TABLE 15 MEAN IRON CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS													
	1 M1		2 Above Lynx Pond		3 Below Lynx Pond		4 Above Myra Ponds Discharge		5 Pumphouse		6 Below Diversion Ditches		7 M2	
	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
x̄	< 0.005	0.005	0.010	0.005	0.017	0.006	0.006	0.006	0.016	0.017	0.021	0.007	0.015	0.009
s	0	0.002	0.009	0.002	0.003	0.001	0.003	0.001	0.015	0.001	0.004	0.001	0.002	0.002
May 17, P.M.	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
x̄	0.008	0.007	0.007	< 0.005	0.010	0.006	0.007	0.006	0.088	< 0.005	0.107	< 0.005	0.041	0.010
s	0.004	0.001	0.001	0	0.005	0	0.001	0.001	0.103	0	0.063	0	0.032	0.001
May 18, A.M.	10:00		10:00		10:25		12:30		11:30		12:00		9:00	
x̄	0.008	< 0.005	0.005	< 0.005	0.013	< 0.005	0.008	< 0.005	0.008	< 0.005	0.019	< 0.005	0.023	0.005
s	0.001	0	0.002	0	0.005	0	0.003	0	0.001	0	0.005	0	0.004	0.002
May 18, P.M.	14:45		14:45		15:15		17:45		16:25		16:35		13:45	
x̄	0.024	< 0.005	< 0.005	< 0.005	0.020	< 0.005	0.009	< 0.005	0.302	0.019	0.024	< 0.005	0.015	< 0.005
s	0.024	0	0	0	0.014	0	0.002	0	0.499	0.011	0.006	0	0.003	0
May 19, A.M.	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
x̄	0.016	< 0.005	0.006	< 0.005	0.017	< 0.005	0.018	< 0.005	0.009	< 0.005	0.016	< 0.005	0.022	0.006
s	0.005	0.002	0.004	0	0.002	0	0.004	0.002	0.001	0	0.002	0	0.001	0.006
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
x̄	0.011	< 0.005	0.006	< 0.005	0.025	0.005	0.039	0.007	0.010	0.007	0.060	0.009	0.026	0.010
s	0.003	0	0.006	0	0.025	0.003	0.006	0	0.001	0.004	0.019	0.003	0.005	0.001
Overall														
x̄	0.01[illegible]	< 0.005	0.006	< 0.005	0.017	< 0.005	0.015	< 0.005	0.072	< 0.005	0.041	< 0.005	0.023	0.007
s	0.011	< 0.005	0.005	< 0.005	0.011	< 0.005	0.013	< 0.005	0.206	< 0.005	0.041	< 0.005	0.014	0.004

T. = Total

D. = Dissolved

s = Standard Deviation

Note: To calculate mean and standard deviation one half the detection limit (0.0025 mg/l) was used when sample concentrations were less than the detection limit (< 0.001 mg/l).

Iron concentrations fluctuated greatly over the three day sampling period and significant increases in concentrations were never noted consistently at any one place on all three days. However, the overall mean for the three day sampling survey shows a two-fold increase in total iron levels from site #1 to site #7.

Results from the Sirco composite samples further exemplify the great variability in iron concentrations (Table 16). Average total iron concentrations for the Sirco composite samples collected during the 24-hour period beginning 9:00 AM May 18 ranged from 0.013 to 0.092 mg/l. The maximum variation during that period was 0.208 mg/l. Average total iron concentrations for the Sirco composite samples collected during the 24-hour period beginning 9:00 AM May 19 ranged from 0.013 to 0.069 mg/l. The maximum variation during that period was 0.083 mg/l.

3.3 Additional Sampling Sites

3.3.1 Kelso Creek. Kelso Creek, a significant stream of runoff from the tailings road that emptied into Myra Creek approximately thirty meters upstream of M2, typified acid mine drainage (Table 17). The pH was low (4.9). Conductivity, residues and most metal levels were high. Total residue was made up almost entirely of filterable residue. Solubility of metals increases when pH is low. As expected, dissolved copper, zinc and cadmium concentrations equalled the corresponding total metal concentrations. Dissolved aluminum and dissolved iron made up a comparingly smaller fraction of the total aluminum and total iron concentrations. Total hardness was high with Ca^{++}, Mg^{++} hardness making up about 67% of the total.

3.3.2 South Bank at Site 9C of Initial Conductivity Transect Survey. A grab sample was collected from the south shore of site 9C to determine if the high conductivities recorded there may have been attributed to a particular parameter(s) (Table 18). Turbidity and sulphate concentrations

TABLE 16 MEAN TOTAL IRON CONCENTRATIONS (mg/l) FROM SIRCO SAMPLES COLLECTED MAY 17 THROUGH TO MAY 20, 1983 AT SITE #7-M2

DATE	TIME		
May 17	9:00 - 11:00	0.020	*
		$\bar{x}$**	s
May 18	9:00 - 11:00	0.015	0.001
	12:00 - 14:00	0.015	0.002
	15:00 - 17:00	0.092	0.128
	18:00 - 20:00	0.015	0.001
	21:00 - 23:00	0.015	0.002
May 18-19	24:00 - 2:00	0.016	0.004
	3:00 - 5:00	0.013	0.001
	6:00 - 8:00	0.016	0.002
May 19	9:00 - 11:00	0.013	0.003
	12:00 - 14:00	0.017	0.005
	15:00 - 17:00	0.019	0.003
	18:00 - 20:00	0.045	0.011
	21:00 - 23:00	0.069	0.025
May 19-20	24:00 - 2:00	0.047	0.011
	3:00 - 5:00	0.058	0.007
	6:00 - 8:00	0.054	0.023

*On May 17, samples were collected for only the first three consecutive hours, 9:00 - 11:00 inclusive, were then combined and analyzed as one sample for total metals.

**On May 18 and 19, samples from three consecutive hours were combined, mixed and then split to provide three replicate samples for total metal analysis.

TABLE 17 PHYSICAL AND CHEMICAL MEASUREMENTS FROM A SINGLE GRAB SAMPLE COLLECTED IN 'KELSO' CREEK ON MAY 17, 1983

PARAMETER*	RESULT
Temperature (°C)	-
pH (relative units)	4.91
Turbidity (FTU)	7.5
Conductivity (lab) (umhos/cm)	293
Conductivity (field) (umhos/cm)	-
Filterable Residues	223
Non-Filterable Residues	26
Total Residues	249
Sulphates	-
Total Copper	1.46
Dissolved Copper	1.50
Total Zinc	5.76
Dissolved Zinc	5.76
Total Cadmium	0.028
Dissolved Cadmium	0.027
Total Lead	0.003
Dissolved Lead	< 0.001
Total Aluminum	8.64
Dissolved Aluminum	5.77
Total Iron	1.57
Dissolved Iron	0.15
Hardness Ca, Mg	89.6
Total Hardness	133.0

*All units mg/l except where indicated otherwise.

TABLE 18 PHYSICAL AND CHEMICAL MEASUREMENTS FROM A SINGLE GRAB SAMPLE COLLECTED IN A POOL ON THE SOUTH BANK OF SITE 9C ON MAY 18, 1983

PARAMETER*	RESULT
Temperature (°C)	5.7
pH (relative units)	6.7
Turbidity (FTU)	0.7
Conductivity (lab) (umhos/cm)	73.1
Conductivity (field) (umhos/cm)	148
Filterable Residues	50
Non-Filterable Residues	< 5
Total Residues	53
Sulphates	19.0
Total Copper	0.009
Dissolved Copper	0.009
Total Zinc	0.089
Dissolved Zinc	< 0.002
Total Cadmium	< 0.0005
Dissolved Cadmium	< 0.0005
Total Lead	< 0.001
Dissolved Lead	< 0.001
Total Aluminum	0.2
Dissolved Aluminum	< 0.05
Total Iron	0.16
Dissolved Iron	< 0.005
Hardness Ca, Mg	-
Total Hardness	-

*All units mg/l except where indicated otherwise.

at this site was the highest recorded in the study. Filterable and total residues were high. Both total copper and total zinc concentrations were the highest recorded in the study with tne exception of Kelso Creek concentrations. Total zinc concentrations were almost twice as high as concentrations recorded at M2. Cadmium, lead, aluminum, iron and hardness were all very low. Therefore, the higher conductivity recorded along the south shore of site #4 may be attributed to high residues, sulphates and more importantly copper and zinc levels.

3.3.3 South Bank of Water Sampling Site #4. Conductivity along the south bank upstream of Myra ponds discharge (water sampling site #4) was noticeably higher, throughout most of the study, than the conductivity in midstream at this site. On May 19 three grab samples, one above and two below site #4, were collected to determine if the high conductivities could be attributed to any particular parameter (Table 19).

Total residues, made up almost entirely of the filterable (dissolved) fraction, were high. The sulphate concentration was high fifteen meters downstream of site #4 and five meters upstream of site #4. Total aluminum concentrations fifteen meters downstream of site #4 were the highest recorded in the study. Total iron was very high at the site fifteen meters downstream of site #4. Total and Ca^{++}, Mg^{++} hardness values were greater at fifteen meters downstream of site #4 and five meters upstream of site #4 than at M2. Copper and zinc concentrations were comparable to and less than levels recorded in midstream at site #4. Therefore, the higher conductivity recorded along the south shore of site #4 can be attributed to high residue, sulphate and hardness concentrations and in some instances to high total aluminum and total iron concentrations.

3.3.4 Campbell River at Gold River Bridge and Campbell River in Elk Falls Provincial Park. The only parameter that appeared unusually high at either site was total and dissolved zinc (Table 20). In May 1983

TABLE 19 CHEMICAL MEASUREMENTS FROM SINGLE GRAB SAMPLES COLLECTED ON THE SOUTH BANK OF SITE #4 ON MAY 19, 1983

PARAMETER*	FIVE METERS UPSTREAM RESULT	FIVE METERS DOWNSTREAM RESULT	FIFTEEN METERS DOWNSTREAM RESULT
Turbidity (FTU)	< 0.1	< 0.1	< 0.1
Conductivity (lab) (umhos/cm)	83.7	61.5	82.7
Conductivity (field) (umhos/cm)	68	71	77
Filterable Residues	57	43	58
Non-Filterable Residues	< 5	< 5	< 5
Total Residues	58	43	59
Sulphates	23.4	4.4	23.1
Total Copper	0.002	0.001	0.002
Dissolved Copper	0.001	< 0.001	0.001
Total Zinc	0.005	0.005	0.006
Dissolved Zinc	0.004	0.003	0.006
Total Cadmium	< 0.0005	< 0.0005	< 0.0005
Dissolved Cadmium	< 0.0005	< 0.0005	< 0.0005
Total Lead	< 0.001	< 0.001	0.002
Dissolved Lead	< 0.001	< 0.001	< 0.001
Total Aluminum	0.06	0.05	0.11
Dissolved Aluminum	< 0.05	< 0.05	< 0.05
Total Iron	0.013	0.023	0.119
Dissolved Iron	0.005	0.007	0.016
Hardness Ca, Mg	33.3	22.5	32.1
Total Hardness	33.6	22.7	32.3

*All units mg/l except where indicated otherwise.

TABLE 20 CHEMICAL PARAMETERS FROM REPLICATED GRAB SAMPLES IN THE CAMPBELL RIVER ON MAY 19, 1983

PARAMETERS	AT GOLD RIVER BRIDGE		IN ELK FALLS PROVINCIAL PARK	
	$\bar{x}$	S	$\bar{x}$	S
Turbidity (FTU)	< 0.1	0	< 0.01	0
Conductivity (lab) umhos/cm	60.1	0.6	47.2	0
Filterable Residues	38	4	34	4
Non-Filterable Residues	< 5	0	< 5	0
Total Residues	39	3	35	3
Sulphates	5.1	0.1	4.1	0.1
Total Copper	0.002	0.001	0.002	0.001
Dissolved Copper	0.002	0	0.001	0
Total Zinc	0.055	0.002	0.033	0.001
Dissolved Zinc	0.046	0.002	0.030	0.002
Total Cadmium	< 0.0005	0	< 0.0005	0
Dissolved Cadmium	0.0003	0.0001	< 0.0005	0
Total Lead	< 0.001	0	< 0.001	0
Dissolved Lead	< 0.001	0	< 0.001	0
Total Aluminum	< 0.05	0	< 0.05	0
Dissolved Aluminum	< 0.05	0	< 0.05	0
Total Iron	0.020	0.007	0.053	0.010
Dissolved Iron	0.006	0.001	0.022	0.001
Hardness Ca, Mg	23.9	1.0	19.4	0.8
Total Hardness	24.1	1.0	19.6	0.9

levels of total and dissolved zinc in Campbell River at the Gold River Bridge were comparable to the levels recorded at M2 in Myra Creek. However, the average total zinc concentration in the Campbell River at Gold River Bridge had decreased considerably from May 1982 (0.115 mg/l) to May 1983 (0.055 mg/l). Dissolved zinc had decreased from 0.107 mg/l in May 1982 to 0.046 mg/l in May 1983. Average total and dissolved zinc concentrations in the Campbell River at the Gold River Bridge have been as follows:

	May/82	July/82	Oct./82	May/83
total Zn (mg/l)	0.115	0.068	0.046	0.055
dissolved Zn (mg/l)	0.107	0.063	0.049	0.046

(Results of EPS surveys - personal communication with B. Kelso)

In May 1983 levels of total and dissolved zinc in the Campbell River at the Elk Falls Provincial Park site were comparable to the levels recorded in Myra Creek below the Lynx treatment system. Zinc levels have not differed greatly between May 1982 and May 1983. Average total and dissolved zinc concentrations in the Campbell River in Elk Falls Provincial Park have been as follows:

	May/82	July/82	Oct./82	May/83
total Zn (mg/l)	0.043	0.042	0.026	0.033
dissolved Zn (mg/l)	0.045	0.040	0.026	0.030

(Results of EPS surveys - personal communication with B. Kelso)

4 MEAN COPPER, ZINC AND SULPHATE LOADINGS IN MYRA CREEK AND TO MYRA CREEK FROM VARIOUS SOURCES

The major increase in copper and zinc loadings in Myra Creek was below the Lynx Pond discharge and another small increase was noted at M2. The major increase in sulphate loading was at the pumphouse below the Myra ponds, discharge. Smaller increases in sulphate loadings were noted below the Lynx pond discharge and at M2 (Table 21).

The metal and sulphate loadings from the pond discharges did not account for all of the increase in loadings noted in Myra Creek downstream of the ponds (Table 22). Site drainage or pond seepage accounted for 63% of the dissolved copper loadings, 74% of the total zinc loadings and 92% of the dissolved zinc loadings seen below the Lynx Pond discharge. Site drainage or pond seepage accounted for approximately 6% of the total zinc loadings at the pumphouse below the Myra Ponds discharge. Lastly, site drainage accounted for 49% of the total copper loadings, 57% of the dissolved copper loadings, 59% of the total zinc loadings, 77% of the dissolved zinc loadings, and 19% of the sulphate loadings noted at M2. Therefore, site drainage or pond seepage accounted for a major portion of the metal loadings in Myra Creek below the Lynx pond discharge, and for a major portion of the metal loadings between the pumphouse below Myra Ponds discharge and M2.

Total copper loadings in Myra Creek at sites #4, #5 and #7 or sites MC1, MC2 and M2, respectively (Kelso and Jones, 1983) were between 2 and 3 times less in May 1983 (Table 21) than in December 1982 (Table 23[1]). Total zinc loading in Myra Creek at these sites were 3 to 4 times less in May 1983 (Table 21) than in December 1982 (Table 23).

[1]Amendment to Table 11, page 22, Kelso and Jones, 1983.

TABLE 21 MEAN COPPER, ZINC AND SULPHATE LOADINGS IN MYRA CREEK

	#2 200 m Above Lynx Pond Discharge	#3 400 m Below Lynx Pond Discharge	#4 Above Myra Ponds Discharge	#5 Pumphouse	#7 M2
Concentration (mg/l)					
total copper	< 0.001	0.004	0.003	0.003	0.005
dissolved copper	< 0.001	0.003	0.003	0.002	0.005
total zinc	< 0.002	0.029	0.021	0.024	0.052
dissolved zinc	< 0.002	0.015	0.014	0.009	0.035
sulphates	2.3	4.75	4.42	11.2	12.03
Flow (m^3/sec)	5.60	5.71	5.71	6.05	6.64*
Loadings (kg/day)					
total copper	< 0.48	1.97	1.48	1.57	2.87
dissolved copper	< 0.48	1.48	1.48	1.05	2.87
total zinc	< 0.97	14.31	10.36	12.54	29.83
dissolved zinc	< 0.97	7.40	6.91	4.70	20.08
sulphates	1113	2543	2181	5854	6902

*Staff gauge readings were recorded at M2 both in the morning and afternoon of May 17 through to the 19. Gauge readings were converted to flow rates using Stage Discharge Curve 3 for Myra Creek - Lower as prepared by Norecol. Flows at the other four sites were estimated as follows: flow at site #5 (Pumphouse) equalled 0.91 x flow at M2 (B. Kelso and Jones, 1983); flow at site #4 (Above Myra Ponds Discharge) equalled estimated flow at site #5 minus flow from Myra Ponds (0.34 m^3/S); flow at site #3 equalled flow at site #4; flow at site #2 equalled estimated flow at site #3 minus flow from Lynx Pond (0.11 m^3/S).

TABLE 22 COPPER, ZINC AND SULPHATE LOADINGS (kg/day) TO MYRA CREEK FROM EFFLUENT DISCHARGES AND SITE DRAINAGE OR POND SEEPAGE

	Site #2			Site #3	Site #4			Site #5		Site #7
	Above Lynx Ponds Discharge	Lynx Ponds* Effluent	Site Drainage or Pond Seepage	Below Lynx Pond Discharge	Above Myra Ponds Discharge	Myra Ponds* Effluent	Site Drainage or Pond Seepage	Below Myra Ponds Discharge	Site Drainage	M2
total copper	< 0.48	2.88	-	1.97	1.48	< 0.11	-	1.46	1.41	2.87
dissolved copper	< 0.48	0.55	0.93	1.48	1.48	< 0.11	-	1.22	1.65	2.87
total zinc	< 0.97	3.70	10.60	14.31	10.36	1.10	0.68	12.14	17.69	29.83
dissolved zinc	< 0.98	0.58	6.82	7.40	6.91	0.09	-	4.68	15.40	20.08
sulphate	1113	2380	-	2543	2181	10600	-	5620	1282	6902

*Results from effluent sampling May 17-19 by K. Ferguson, E.P.S.

TABLE 23 TOTAL ZINC AND TOTAL COPPER LOADINGS FROM APRIL 1982 AND DECEMBER 1982 AT EACH OF THE SAMPLE SITES WITHIN AND DOWNSTREAM OF THE WESTMIN MINE

STATION	MYRA POND EFFLUENT	MC1	MC2	M2	
	Dec. 7, 1982	Dec. 7, 1982	Dec. 7, 1982	Dec. 7, 1982	April 16, 1982
Flow (m^3/sec)	0.152[1]	3.53[3]	3.69[5]	4.05**	3.06[6]
Concentration (mg/l)					
Zn	0.259[2]	0.137[4]	0.162	0.290	1.90
Cu	0.027[2]	0.012[4]	0.013	0.024	0.217
Loadings (kg/day)					
Zn	3.4	41.8	51.6	101.5	502.3
Cu	.35	3.66	4.14	8.4	57.4

**The staff gauge reading was 46.5 cm for December 7, 1982. Flow at M2 on December 7, 1982 should have been estimated using the stage discharge curve 3 as prepared by Norecol for Westmin Resources and not the stage discharge curve 2 from the Hydrology Report of B.C. Research Phase II Monitoring Report. This is the corrected value from Kelso and Jones, 1983.

[1]Based on influent flow taken from the Stage II, Addendum 1 Westmin Resources Ltd. 1982.
[2]Unpublished data - Keith Ferguson, Environmental Protection Service, Dec. 7, 1982.
[3]MC2 flow less the Myra Pond effluent estimate which was based on the influent flow.
[4]Mean of both morning and afternoon sampling of north and south banks.
[5]Calculated by using .91 times M2 flow (personal communication B. Hallam, Westmin).
[6]Based on gauge reading, 32.0 cm for April 16/82 and using the stage discharge curve 1 from the Hydrology Report of B.C. Research Phase II Monitoring Report.

5. SUMMARY AND CONCLUSIONS

5.1 Relationship Between Conductivty and other Chemical Parameters

Conductivity recorded in the field with the 4000 series Hydrolab unit was used to indicate trends or patterns for dilution and dispersion of the treatment system discharges, pond seepages and site drainage in Myra Creek. The following pattern emerged over the three day sampling survey: there was a small increase in conductivity below the Lynx Pond discharge (site #3); at the pumphouse below Myra Ponds discharge (site #5); another small increase in conductivity was noted at (site #7) on May 18 and 19.

The significant increase in conductivity below the Myra ponds discharge may be related to a corresponding increase in residue, sulphate and hardness concentrations. In fact, sulphate loadings increased most significantly at the pumphouse below the Myra Ponds discharge and could be attributed entirely to the Myra Ponds effluent. The small increase in conductivity below the Lynx pond was related to a corresponding increase in sulphate, copper and zinc levels.

Copper and zinc loadings increased most significantly below the Lynx Pond discharge. All the total copper loading could be attributed to the Lynx Pond effluent but some dissolved copper loadings and a major portion of the total and dissolved zinc loading appeared to be introduced further from site drainage or pond seepage. A small increase in sulphate loadings below the Lynx Pond discharge was attributed entirely to the Lynx Pond effluent.

Any small increase in conductivity noted at M2 may also be related to a corresponding increase in sulphates, copper and zinc concentrations. Copper and zinc loadings increased noticeably at M2 and most of the increase was attributed to site drainage. The small increase in sulphate loading at M2 was also attributed to site drainage.

There appears to be two types of contaminant sources that elevated conductivity levels in Myra Creek. The Lynx pond discharge and the runoff or seepage from the mining/milling site mainly increased sulphate, copper and zinc concentrations in Myra Creek that subsequently increased conductivity levels. The Myra ponds discharge increased residue, sulphate and hardness levels and thereby increased conductivity levels. The higher conductivity recorded along the south shore of site #4 across from the Myra treatment ponds, appears to be mainly attributed to high residue, sulphate and hardness concentrations. Therefore, seepage from the Myra ponds is suspected as the source of contamination. In comparison, site drainage may be affecting the south bank of site 9C because the high conductivity reading was mainly attributed to high residue, sulphate and more importantly the highest recorded copper and zinc levels in Myra Creek.

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APPENDIX I

SEDIMENT SAMPLE RESULTS FOR MYRA CREEK AT M1 AND M2

HEAVY METAL CONCENTRATION, PARTICLE SIZE DISTRIBUTION AND VOLUME OF INTERGRAVEL FINE SEDIMENTS FOR M1

METAL*	REPLICATION NUMBER 1	2	3
Hg**	.64	.35	.34
As	< 40	24	29
Ba	100	133	152
Be	< .8	< .2	.4
Cd	< 2	.7	.7
Co	21	14.4	15.6
Cr	91	42	81.3
Cu	73	70.7	78.7
Mn	921	708	1040
Mo	< 4	< .8	< .8
Ni	50	19	38
P	530	515	603
Pb	< 20	19	19
Sn	< 8	3	2
Sr	46.7	40.6	43.7
Ti	1270	1160	1440
V	84	77	97
Zn	93	125	148
Al	24900	29000	34200
Fe	26200	25600	32400
Si	13300	4650	3580
Ca	9460	9930	9690
Mg	7580	8350	9490
Na	700	350	370

*ICAP, < 0.15 mm fraction, as ug/g (ppm)
**Hg (flameless atomic absorption)

Portion of total Sample (%)			
> .15 mm	78.7	61.4	57.7
< .15 mm	21.3	38.6	42.3
Portion of total Sample (weight:g)			
> .15 mm	.3	1.7	1.9
< .15 mm	.1	1.1	1.4
Sample Volume :ml			
total liq. & settleable	1230	1150	1265
total settleable	3	12	7.5

Note: replication 1 had a very small amount of sample for some reason.

HEAVY METAL CONCENTRATION, PARTICLE SIZE DISTRIBUTION AND VOLUME OF INTERGRAVEL FINE SEDIMENTS FOR M2

METAL*	REPLICATION NUMBER 1	2	3
Hg**	.77	.73	.90
As	19	25	24
Ba	1840	2290	1320
Be	.5	.5	.5
Cd	8.5	9.3	9.6
Co	23.9	24	25
Cr	52.9	45.7	69.2
Cu	900	965	1350
Mn	1440	1460	1400
Mo	< .8	< .8	< .8
Ni	30	28	43
P	594	602	443
Pb	155	174	146
Sn	< 2	< 2	< 2
Sr	65.8	67.4	56.8
Ti	1990	1790	1970
V	122	116	121
Zn	3260	3510	4810
Al	37300	37300	37200
Fe	45200	45100	42300
Si	3820	4040	3260
Ca	11300	11000	11100
Mg	16000	15900	17000
Na	400	390	390

*ICAP, < 0.15 mm fraction, as ug/g (ppm)
**Hg (flameless atomic absorption)

Portion of total Sample (%)			
> .15 mm	63.3	74.2	84.2
< .15 mm	36.7	25.8	15.8
Portion of total Sample (weight:g)			
> .15 mm	2.6	5.8	1.7
< .15 mm	1.5	2.0	0.3
Sample Volume :ml			
total liq. & settleable	1275	1280	1250
total settleable	11	16	20

APPENDIX II

MEAN LAB CONDUCTIVITY RESULTS

MEAN LAB CONDUCTIVITY READINGS (umhos/cm) AT 25°C FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS						
	1 M1	2 Above Lynx Pond	3 Below Lynx Pond	4 Above Myra Ponds Discharge	5 Pumphouse	6 Below Diversion Ditches	7 M2
May 17, A.M.	10:20	13:30	10:45	12:40	11:35	12:00	9:00
E	20.0	25.0	34.8	32.3	51.9	59.3	55.2
S	0	0	0	0.7	0	0	0.2
May 17, P.M.	15:05	17:50	15:33	15:55	16:45	17:20	14:00
E	20.5	25.7	35.8	35.1	56.1	62.2	59.3
S	0	0	0	0	0.6	0	0
May 18, A.M.	10:00	10:00	10:25	12:30	11:30	12:00	9:00
E	19.8	25.5	33.6	34.7	55.8	59.4	60.4
S	0	0	0	0	0	0	0.6
May 18, P.M.	14:45	14:45	15:15	17:45	16:25	16:35	13:45
E	20.4	25.0	35.4	34.9	56.6	61.2	61.0
S	0	0.3	0.3	0.4	0	0.5	0
May 19, A.M.	9:55	10:00	10:35	12:20	11:35	11:45	8:50
E	20.1	25.7	32.3	32.0	52.6	57.5	60.4
S	0.7	0	0.1	0	0	0	0.6
May 19, P.M.	14:00	14:00	14:10	15:40	15:00	15:20	13:00
E	18.6	25.8	30.8	30.6	48.6	56.4	57.5
S	0.2	0	0	0	0.1	0	0

APPENDIX III

METAL CONCENTRATIONS IN MYRA CREEK, May 17-19, 1983

HEAVY METALS THAT WERE BELOW THE DETECTION LIMIT (mg/l)

METAL	DETECTION LIMIT
Arsenic	0.05
Beryllium	0.001
Cobalt	0.005
Chromium[1]	0.005
Molybdenum[2]	0.005
Nickel[3]	0.02
Phosphorus[4]	0.05
Antimony	0.05
Selenium	0.05
Tin[5]	0.01
Vanadium	0.01

[1]On the afternoon of May 18, at site #5, one triplicate sample had a chromium concentration of 0.009 mg/l.

[2]On the afternoon of May 17, at site #5, one triplicate sample had a molybdenum concentration of 0.005 mg/l. On the afternoon of May 19, at site #7, one triplicate sample had a molybdenum concentration of 0.006 mg/l.

[3]On the afternoon of May 17 at site #5, and on the afternoon of May 19 at site #1, one triplicate sample had a nickel concentration of 0.03 mg/l. On the afteroon of May 19 at sites #3 and #7 one triplicate sample had a nickel concentration of 0.02 mg/l.

[4]On the morning of May 17, at site #7, one triplicate sample had a phosphorous concentration of 0.10 mg/l. On the afternoon of May 17, at site #1, one triplicate sample had a phosphorus concentration of 0.06 mg/l.

[5]On the afternoon of May 17 at site #2 and on the afternoon of May 18 at site #1 two triplicate samples had tin concentrations of 0.01 mg/l. On the afternoon of May 18 at site #2, one triplicate sample had a tin concentration of 0.01 mg/l.

MEAN BARIUM CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS													
	1 M1		2 Above Lynx Pond		3 Below Lynx Pond		4 Above Myra Ponds Discharge		5 Pumphouse		6 Below Diversion Ditches		7 M2	
	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
$\bar{x}$	0.003	0.003	0.003	0.003	0.005	0.003	0.005	0.004	0.006	0.005	0.005	0.005	0.006	0.006
S	0	0	0.001	0	0.001	0	0.002	0.001	0	0	0.001	0.001	0	0.001
May 17, P.M.	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
$\bar{x}$	0.003	0.003	0.003	< 0.001	0.005	0.004	0.003	0.004	0.006	0.003	0.007	0.002	0.006	0.006
S	0	0	0.001	0	0.001	0.001	0	0	0.001	0.001	0.002	0	0.001	0
May 18, A.M.	10:00		10:00		10:25		12:30		11:30		12:00		9:00	
$\bar{x}$	0.003	< 0.001	0.003	< 0.001	0.005	< 0.001	0.004	< 0.001	0.005	< 0.001	0.005	< 0.001	0.007	0.002
S	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0.001
May 18, P.M.	16:45		14:45		15:15		17:45		16:25		16:35		13:45	
$\bar{x}$	0.004	< 0.001	0.003	< 0.001	0.005	< 0.001	0.004	< 0.001	0.006	0.002	0.006	0.001	0.006	0.002
S	0	0.001	0	0	0.001	0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003
May 19, A.M.	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
$\bar{x}$	0.004	< 0.001	0.003	< 0.001	0.006	< 0.001	0.007	0.001	0.006	< 0.001	0.006	< 0.001	0.007	0.001
S	0.001	0	0	0	0.001	0	0.004	0.001	0	0.001	0	0.001	0.001	0.001
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
$\bar{x}$	0.005	0.003	0.003	0.003	0.009	0.003	0.005	0.004	0.006	0.004	0.007	0.005	0.006	0.006
S	0.001	0	0.001	0	0.006	0	0.001	0	0.001	0	0.002	0.001	0.001	0
Overall														
$\bar{x}$	0.004	0.002	0.003	0.001	0.006	0.002	0.005	0.002	0.006	0.002	0.006	0.002	0.007	0.004
S	0.001	0.001	0	0.001	0.003	0.001	0.002	0.002	0.001	0.002	0.001	0.002	0.001	0.002

Note: To calculate mean and standard deviation one half the detection limit (0.0005 mg/l) was used when sample concentrations were less than the detection limit (< 0.001 mg/l).

MEAN BORON CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS													
	1 M1		2 Above Lynx Pond		3 Below Lynx Pond		4 Above Myra Ponds Discharge		5 Pumphouse		6 Below Diversion Ditches		7 M2	
	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
$\bar{x}$	< 0.001	< 0.001	0.001	0.003	< 0.001	0.003	< 0.001	0.003	< 0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001
S	0	0	0.001	0.004	0	0.004	0	0.004	0	0.004	0	0	0	0
May 17, P.M.	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
$\bar{x}$	0.002	< 0.001	0.015	0.002	0.002	< 0.001	0.011	< 0.001	0.015	< 0.001	0.013	< 0.001	0.001	< 0.001
S	0.001	0	0	0.002	0.001	0	0.010	0	0	0	0.004	0	0.001	0
May 18, A.M.	10:00		10:00		10:25		12:30		11:30		12:00		9:00	
$\bar{x}$	0.012	0.006	0.024	0.008	0.024	0.006	0.022	< 0.001	0.022	0.004	0.024	0.003	0.012	0.002
S	0	0.003	0	0	0	0.003	0.004	0	0.004	0.003	0	0.004	0.008	0.002
May 18, P.M.	14:45		14:45		15:15		17:45		16:25		16:35		13:45	
$\bar{x}$	0.018	0.005	0.012	0.003	0.018	0.004	0.007	0.003	0.012	< 0.001	0.008	< 0.001	0.016	0.004
S	0.010	0	0	0.002	0.006	0.003	0.006	0.004	0	0	0.006	0	0.014	0.003
May 19, A.M.	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
$\bar{x}$	< 0.001	0.006	0.001	0.002	< 0.001	0.007	0.002	0.007	0.003	0.007	0.003	0.005	0.007	0.004
S	0	0.005	0.001	0.003	0	0.003	0.001	0.006	0	0.006	0	0.007	0.006	0.006
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
$\bar{x}$	0.001	< 0.001	< 0.001	0.001	0.001	0.004	< 0.001	0.003	< 0.001	0.001	< 0.001	< 0.001	0.003	< 0.001
S	0.001	0	0	0.001	0.001	0.003	0	0.002	0	0.001	0	0	0	0
Overall														
$\bar{x}$	0.006	0.003	0.009	0.003	0.008	0.004	0.007	0.003	0.009	0.003	0.008	0.002	0.007	0.002
S	0.008	0.003	0.009	0.003	0.010	0.003	0.009	0.004	0.008	0.004	0.009	0.003	0.008	0.003

Note: To calculate mean and standard deviation one half the detection limit (0.0005 mg/l) was used when sample concentrations were less than the detection limit (< 0.001 mg/l).

MEAN CALCIUM CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS													
	1 M1		2 Above Lynx Pond		3 Below Lynx Pond		4 Above Myra Ponds Discharge		5 Pumphouse		6 Below Diversion Ditches		7 M2	
	T.	B.	T.	B.	T.	B.	T.	B.	T.	B.	T.	B.	T.	B.
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
I	3.1	3.1	3.9	4.0	5.0	5.2	4.8	5.0	7.5	7.8	9.0	9.3	8.1	8.4
S	0	0.1	0	0.1	0	0.1	0.1	0	0.1	0.1	0.1	0.1	0.2	0.1
May 17, P.M.	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
I	3.1	3.2	4.2	< 0.1	5.0	5.2	5.1	5.1	8.3	3.7	9.7	4.6	8.5	8.7
S	0.1	0	0.1	0	0	0.1	0.1	0.1	0.1	0.5	0.1	0.1	0.3	0
May 18, A.M.	10:00		10:00		10:25		12:30		11:30		12:00		9:00	
I	3.1	< 0.1	4.1	< 0.1	4.9	< 0.1	5.1	0.2	8.2	< 0.1	9.6	0.7	9.0	2.9
S	0	0	0.1	0	0	0	0.1	0.3	0.1	0	0.1	0.5	0.1	2.4
May 18, P.M.	14:45		14:45		15:15		17:45		16:25		16:35		13:45	
I	3.1	0.9	3.9	< 0.1	5.1	< 0.1	5.1	2.1	8.4	2.8	9.7	4.4	9.1	1.3
S	0.1	1.8	0.1	0	0.1	0	0.1	2.2	0	2.3	0.2	0.7	0	1.3
May 19, A.M.	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
I	3.1	1.4	4.4	< 0.1	4.9	0.1	4.7	3.2	8.2	1.9	9.4	3.7	8.9	2.2
S	0.1	2.5	0.1	0	0.1	0.1	0.1	2.6	0.1	1.6	0.2	0.5	0.1	1.9
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
I	3.0	2.8	4.3	4.0	4.6	4.0	4.4	4.4	7.4	6.6	8.9	8.7	8.8	8.8
S	0.1	0	0	0.2	0.1	0.1	0.1	0	0	0.2	0	0.3	0.1	0.3
Overall														
I	3.1	1.9	4.1	1.4	4.9	2.4	4.9	3.3	8.0	3.8	9.4	5.2	8.7	5.3
S	0.1	1.6	0.2	1.9	0.1	2.5	0.3	2.2	0.4	2.9	0.4	3.1	0.4	3.5

Note: To calculate mean and standard deviation one half the detection limit (0.0005 mg/l) was used when sample concentrations were less than the detection limit (< 0.001 mg/l).

MEAN MANGANESE CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS													
	1 M1		2 Above Lynx Pond		3 Below Lynx Pond		4 Above Myra Ponds Discharge		5 Pumphouse		6 Below Diversion Ditches		7 M2	
	T.	B.	T.	B.	T.	B.	T.	B.	T.	B.	T.	B.	T.	B.
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
X	< 0.001	< 0.001	< 0.001	< 0.001	0.007	0.006	0.004	0.004	0.004	0.003	0.004	0.002	0.007	0.007
S	0	0	0	0	0	0.001	0	0	0.001	0	0	0.001	0.001	0.001
May 17, P.M.	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
X	< 0.001	< 0.001	< 0.001	< 0.001	0.008	0.008	0.004	0.005	0.004	0.001	0.007	0.001	0.007	0.007
S	0	0.001	0	0	0	0	0	0	0.001	0	0.003	0	0.001	0
May 18, A.M.	10:00		10:00		10:25		12:30		11:30		12:00		9:00	
X	< 0.001	< 0.001	< 0.001	0.001	0.008	0.003	0.006	0.002	0.003	< 0.001	0.004	< 0.001	0.007	0.002
S	0	0	0	0.001	0	0.002	0	0.001	0	0	0.001	0	0	0.001
May 18, P.M.	14:45		14:45		15:15		17:45		16:25		16:35		13:45	
X	< 0.001	< 0.001	< 0.001	< 0.001	0.009	0.004	0.006	0.002	0.005	< 0.001	0.003	< 0.001	0.007	0.002
S	0	0	0	0	0.001	0.003	0	0.001	0.002	0	0.001	0	0	0.001
May 19, A.M.	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
X	< 0.001	0.001	< 0.001	< 0.001	0.009	0.004	0.007	0.003	0.003	< 0.001	0.003	< 0.001	0.006	0.002
S	0	0.001	0	0	0	0.003	0	0.003	0	0	0	0	0	0.001
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
X	< 0.001	< 0.001	< 0.001	< 0.001	0.010	0.006	0.006	0.006	0.003	0.002	0.004	0.002	0.007	0.006
S	0	0	0	0	0.005	0	0.001	0	0	0	0.001	0.001	0	0
Overall														
X	< 0.001	< 0.001	< 0.001	< 0.001	0.009	0.005	0.006	0.004	0.004	0.001	0.004	0.001	0.007	0.004
S	0	0	0	0	0.002	0.003	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.003

Note: To calculate mean and standard deviation one half the detection limit (0.0005 mg/l) was used when sample concentrations were less than the detection limit (< 0.001 mg/l).

MEAN SILICA CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN HYRA CREEK SITES

	STATIONS													
	1		2		3		4		5		6		7	
	M1		Above Lynx Pond		Below Lynx Pond		Above Hyra Ponds Discharge		Pumphouse		Below Diversion Ditches		M2	
	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
X	0.7	0.7	0.7	0.8	0.7	0.8	0.7	0.8	0.8	0.8	0.8	0.9	0.8	0.9
S	0	0.1	0	0	0.1	0	0	0	0.1	0	0.1	0	0	0
May 17, P.M.	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
X	0.7	0.8	0.8	0.3	0.7	0.8	0.7	0.8	0.9	0.4	1.0	0.5	0.9	0.9
S	0	0	0	0.1	0	0	0.1	0	0	0	0.1	0.1	0.1	0
May 18, A.M.	10:00		10:00		10:25		12:30		11:30		12:00		9:00	
X	0.7	< 0.1	0.8	< 0.1	0.8	< 0.1	0.8	< 0.1	0.8	< 0.1	0.9	< 0.1	0.9	0.4
S	0.1	0	0	0	0	0	0	0	0	0	0	0	:	0.1
May 18, P.M.	14:45		14:45		15:15		17:45		16:25		16:35		13:45	
X	0.7	< 0.1	0.8	< 0.1	0.8	< 0.1	0.8	0.1	0.9	< 0.1	0.9	0.1	0.9	0.1
S	0.1	0	0	0	0	0	0	0	0	0	0.1	0	0	0.1
May 19, A.M.	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
X	0.7	< 0.1	0.8	< 0.1	0.8	< 0.1	0.8	0.3	0.8	< 0.1	0.9	0.1	0.9	< 0.1
S	0	0	0	0	0	0	0.1	0.4	0	0	0	0	0	0
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
X	0.7	0.7	0.7	0.8	0.7	0.8	0.8	0.7	0.8	0.8	0.9	0.9	0.9	0.9
S	0	0	0	0	0.1	0	0.1	0	0	0	0	0	0	0
Overall														
X	0.7	0.4	0.8	0.3	0.8	0.4	0.8	0.5	0.8	0.4	0.9	0.4	0.9	0.5
S	0	0.4	0	0.3	0.1	0.4	0.1	0.4	0.1	0.3	0.1	0.4	0	0.4

Note: To calculate mean and standard deviation one half the detection limit (0.05 mg/l) was used when sample concentrations were less than the detection limit (< 0.1 mg/l).

MEAN STRONTIUM CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS													
	1		2		3		4		5		6		7	
	M1		Above Lynx Pond		Below Lynx Pond		Above Myra Ponds Discharge		Pumphouse		Below Diversion Ditches		M2	
	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
$\bar{x}$	0.006	0.006	0.006	0.007	0.011	0.011	0.011	0.011	0.015	0.016	0.014	0.016	0.015	0.016
S	0	0	0	0	0.001	0.001	0.001	0	0.001	0	0	0	0.001	0
May 17, P.M.	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
$\bar{x}$	0.006	0.006	0.007	< 0.001	0.011	0.012	0.011	0.011	0.016	0.009	0.016	0.008	0.015	0.016
S	0	0	0	0	0.001	0.001	0	0.001	0.001	0.001	0	0.001	0.001	0
May 18, A.M.	10:00		10:00		10:25		12:30		11:30		12:00		9:00	
$\bar{x}$	0.006	< 0.001	0.007	< 0.001	0.012	< 0.001	0.012	< 0.001	0.015	< 0.001	0.015	< 0.001	0.016	0.006
S	0.001	0	0	0	0.001	0	0	0	0.001	0	0	0	0	0.004
May 18, P.M.	14:45		14:45		15:15		17:45		16:25		16:35		13:45	
$\bar{x}$	0.007	0.002	0.006	< 0.001	0.012	< 0.001	0.013	0.004	0.016	0.006	0.016	0.007	0.017	0.003
S	0	0.003	0.001	0	0.001	0	0.001	0.002	0	0.004	0.001	0	0	0.002
May 19, A.M.	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
$\bar{x}$	0.006	0.003	0.007	0.001	0.012	0.001	0.012	0.006	0.015	0.003	0.015	0.005	0.017	0.004
S	0	0.004	0	0.001	0	0.001	0.001	0.004	0	0.002	0	0.001	0.001	0.003
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
$\bar{x}$	0.006	0.005	0.007	0.006	0.011	0.010	0.010	0.010	0.014	0.012	0.014	0.014	0.016	0.016
S	0	0.001	0.001	0.001	0.001	0	0.001	0	0	0.001	0	0.001	0	0.001
Overall														
$\bar{x}$	0.006	0.004	0.007	0.003	0.012	0.006	0.011	0.007	0.015	0.008	0.015	0.008	0.016	0.010
S	0	0.003	0.001	0.003	0.001	0.005	0.001	0.004	0.001	0.006	0.001	0.005	0.001	0.006

Note: To calculate mean and standard deviation one half the detection limit (0.0005 mg/l) was used when sample concentrations were less than the detection limit (< 0.001 mg/l).

MEAN TITANIUM CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS													
	1 M1		2 Above Lynx Pond		3 Below Lynx Pond		4 Above Myra Ponds Discharge		5 Pumphouse		6 Below Diversion Ditches		7 M2	
	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
Ā	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
S	0	0	0	0	0	0	0.001	0	0.001	0	0.001	0	0	0
May 17, P.M.	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
Ā	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.005	< 0.002	< 0.002	< 0.002
S	0	0	0	0	0	0	0	0	0	0	0.003	0	0	0
May 18, A.M.	10:00		10:00		10:25		12:30		11:30		12:00		9:00	
Ā	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
S	0	0	0	0	0	0.002	0	0	0	0	0	0	0	0
May 18, P.M.	14:45		14:45		15:15		17:45		16:25		16:35		13:45	
Ā	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
S	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May 19, A.M.	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
Ā	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
S	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
Ā	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.002	< 0.002	< 0.002	< 0.002
S	0.001	0	0	0	0.001	0	0	0	0	0	0.001	0	0	0
Overall														
Ā	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.002	< 0.002	< 0.002	< 0.002
S	0	0	0	0	0	0.001	0	0	0	0	0.002	0	0	0

Note: To calculate mean and standard deviation one half the detection limit (0.001 mg/l) was used when sample concentrations were less than the detection limit (< 0.002 mg/l).

MEAN MAGNESIUM CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS													
	1 M1		2 Above Lynx Pond		3 Below Lynx Pond		4 Above Myra Ponds Discharge		5 Pumphouse		6 Below Diversion Ditches		7 M2	
	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.	T.	D.
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
$\bar{x}$	0.2	0.1	0.2	0.2	0.3	0.3	0.2	0.2	0.3	0.4	0.4	0.4	0.4	0.4
S	0.1	0	0	0	0	0.1	0	0	0.1	0	0	0	0	0
May 17, P.M.	15:05		17:50		15:33		15:55		16:45		17:20		14:00	
$\bar{x}$	0.1	0.1	0.2	< 0.1	0.2	0.3	0.2	0.2	0.4	0.2	0.5	0.2	0.5	0.5
S	0.1	0	0	0	0.1	0	0	0	0	0	0	0	0.1	0
May 18, A.M.	10:00		10:00		10:25		12:30		11:30		12:00		9:00	
$\bar{x}$	0.1	< 0.1	0.2	< 0.1	0.3	< 0.1	0.3	< 0.1	0.3	< 0.1	0.4	< 0.1	0.4	0.2
S	0	0	0	0	0.1	0	0	0	0.1	0	0	0	0	0.1
May 18, P.M.	14:45		14:45		15:15		17:45		16:25		16:35		13:45	
$\bar{x}$	0.1	< 0.1	0.1	< 0.1	0.3	< 0.1	0.2	0.1	0.4	0.1	0.4	0.2	0.4	0.1
S	0	0.1	0	0	0.1	0	0	0.1	0.1	0.1	0	0.1	0	0.1
May 19, A.M.	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
$\bar{x}$	0.1	0.1	0.2	< 0.1	0.3	< 0.1	0.2	0.1	0.3	< 0.1	0.4	0.1	0.4	0.1
S	0	0.1	0	0	0	0	0.1	0.1	0	0	0	0.1	0	0.1
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
$\bar{x}$	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.3	0.4	0.4
S	0.1	0.1	0.1	0.1	0	0	0	0	0	0.1	0	0	0	0
Overall														
$\bar{x}$	0.1	0.1	0.2	0.1	0.3	0.2	0.2	0.1	0.3	0.2	0.4	0.2	0.4	0.3
S	0	0	0	0.1	0.1	0.1	0	0.1	0.1	0.1	0	0.1	0	0.2

Note: To calculate mean and standard deviation one half the detection limit (0.05 mg/l) was used when sample concentrations were less than the detection limit (< 0.1 mg/l).

MEAN SODIUM CONCENTRATIONS (mg/l) FOR THE MORNING AND AFTERNOON OF MAY 17, 18 AND 19, 1983 AT SEVEN MYRA CREEK SITES

	STATIONS													
	1		2		3		4		5		6		7	
	M1		Above Lynx Pond		Below Lynx Pond		Above Myra Ponds Discharge		Pumphouse		Below Diversion Ditches		M2	
	T.	B.	T.	B.	T.	B.	T.	B.	T.	B.	T.	B.	T.	B.
May 17, A.M.	10:20		13:30		10:45		12:40		11:35		12:00		9:00	
X	0.4	0.4	0.4	0.5	0.7	0.8	0.6	0.7	0.7	0.8	0.7	0.8	0.7	0.8
S	0	0	0	0.1	0	0	0.1	0	0	0	0	0	0	0
May 17, P.M.	15:05		17:00		15:33		15:55		16:45		17:20		14:00	
X	0.4	0.5	0.5	< 0.2	0.6	0.8	0.7	0.8	0.8	0.4	0.8	0.4	0.7	0.8
S	0	0.1	0	0	0.1	0.1	0.1	0.1	0	0.1	0	0.1	0.1	0
May 18, A.M.	10:00		10:00		10:25		12:30		11:30		12:00		9:00	
X	0.5	< 0.2	0.5	< 0.2	0.7	< 0.2	0.7	< 0.2	0.8	< 0.2	0.8	< 0.2	0.8	0.3
S	0	0	0.1	0	0	0	0	0	0.1	0	0.1	0	0.1	0.2
May 18, P.M.	16:45		16:45		15:15		17:45		16:25		16:35		13:45	
X	0.5	< 0.2	0.5	< 0.2	0.8	< 0.2	0.7	< 0.2	0.8	0.2	0.7	< 0.2	0.8	< 0.2
S	0	0	0.1	0	0	0	0	0	0	0.1	0.1	0.1	0	0
May 19, A.M.	9:55		10:00		10:35		12:20		11:35		11:45		8:50	
X	0.5	< 0.2	0.5	< 0.2	0.7	< 0.2	0.7	0.3	0.8	< 0.2	0.7	< 0.2	0.7	< 0.2
S	0	0	0	0	0	0	0	0.3	0.1	0	0	0	0	0
May 19, P.M.	14:00		14:00		14:10		15:40		15:00		15:20		13:00	
X	0.5	0.4	0.5	0.4	0.7	0.6	0.6	0.6	0.7	0.6	0.7	0.7	0.7	0.7
S	0	0	0	0.1	0	0	0.1	0	0	0	0	0.1	0	0
Overall														
X	0.5	0.3	0.5	0.2	0.7	0.4	0.7	0.4	0.8	0.4	0.7	0.4	0.7	0.5
S	0	0.2	0.1	0.2	0.1	0.3	0.1	0.3	0.1	0.3	0	0.3	0	0.3

Note: To calculate mean and standard deviation one half the detection limit (0.1 mg/l) was used when sample concentrations were less than the detection limit (< 0.2 mg/l).